COMPARISON OF MODIFIED BIOPHYSICAL PROFILE AND DOPPLER ULTRASONOGRAPHY STUDIES IN PREDICTING PERINATAL OUTCOME IN HIGH-RISK PREGNANCIES

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LIST OF ABBREVATIONS

AFI- Amniotic Fluid Index

AF – Amniotic fluid

MBPP- modified biophysical profile

BPP- Biophysical Profile

NST- Non-Stress Test

CTG- cardiotocography

EGF-Epidermal Growth Factor

TGF-b1-Transforming growth factor beta-1

G-CSF- Granulocyte colony-stimulating factor

IUGR- Intra uterine growth retardation

PPV - positive predictive value

NPV- negative predictive value

UA-Umbilical artery

PI -Pulsatility index

RI -resistance index

S/D -systolic/diastolic ratio

PO2- Partial pressure of O2

CST- Contraction stress Test

OCT- Oxytocin Stress Test

FIGO- The International Federation of Gynecology and Obstetrics

SLE- Systemic lupus erythematosus

APLA-Anti Phospholipid Antibody

RBC- Red blood cells

CWD- Continuous wave doppler

PWD- Pulsed wave Doppler

P value- Probability value

FHR-Fetal Heart Rate

SVP -Single maximal vertical pocket

LSCS- lower segment caesarean section

ANS- Autonomic Nervous System

MCA- Middle cerebral artery

MCA-PSV- middle cerebral artery peak systolic velocity

MCDA-Monochorionic diamniotic

CPR- Cerebro Placental Ratio

FAD - Fetal Activity Determination Test

LF-Lactoferrin

SDP- Single Deepest Pocket

UA-Umbilical artery

ACOG-American college of obstetrics

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ABSTRACT

Background:

Antepartum fetal surveillance is the evaluation of the fetal health during pregnancy, particularly once it has been determined that it is viable.The end goal is to prevent fetal demise and to avoid perinatal morbidity.

Aims and objective of the study:

Primary objective: To compare modified biophysical profile (MBPP)and Doppler flow velocimetry results in pregnant women for prediction of perinatal outcome in term high risk pregnancy.

Secondary objective: to evaluate the association between the mode of delivery and abnormal Doppler and MBPP.

STUDY DESIGN:

Methodology-This is a prospective observational and comparative study..

All high-risk term patients were taken in this study and women were subjected to Doppler study and modified BPP evaluation at term, within 48 to 72 hours of delivery.

Based on the Doppler velocimetry and MBPP results, the study population was divided into four groups:

•A-Normal MBPP and normal Doppler velocimetry

• B-Normal MBPP and abnormal Doppler velocimetry

• C-Abnormal MBPP and normal Doppler velocimetry

• D-Abnormal MBPP and abnormal Doppler velocimetry.

Perinatal outcome was measured in terms of LBW, APGAR score, resuscitation at birth, distress at birth and NICU admission.

RESULTS

150 high risk patients were taken into this study, out of which 88 new-borns had adverse perinatal outcome.

When MBPP was employed as a predictor, 39 newborns had poor perinatal outcome. While the test was false positive in 6 number of cases.

When Doppler study was employed as a predictor, 30 had poor perinatal outcome. the test showed false positive in 2 cases. Combined MBPP and Doppler study when done as a predictor 17 out of 17 had poor perinatal outcome.

NST and Doppler Velocimetry both are sensitive and specific tests with good positive predictive value in predicting adverse neonatal outcome. However, it was seen that the negative predictive value of MBPP is relatively higher which is significant in detecting healthy neonates

CONCLUSION

In our study, it was determined that MBPP, when compared with Doppler is more accurate predictor of perinatal outcome. Even if the Doppler is normal, MBPP should be performed in all high-risk pregnancies regardless of FGR. MBPP can indicate a poor perinatal outcome in a pregnancy complicated by any high-risk factor. Therefore, in order to improve the perinatal outcome, both of these antenatal surveillance tests must be carried out in all high-risk pregnant women**.**

INTRODUCTION

The major goal of antepartum fetal surveillance is to identify the fetus at risk of altered growth and hypoxemia. Linked to this goal is the expectation that improved perinatal outcomes will result. An equally important goal is the correct identification of the fetus which is well and requiring no immediate intervention. Avoidance of unnecessary intervention is the basis of any protocol for surveillance of high-risk pregnancy.

Biophysical Physical Profile (BPP) described by Manning assesses five different fetal parameters to assess fetal well-being, which include a non-stress test, fetal movements, fetal muscle tone, fetal breathing movement, and amniotic fluid volume[(1)]. The limitation of the BPP is that it is time-consuming, taking an average of 30 minutes for the procedure[(2)].

In modified BPP, the same goal is achieved using two parameters. Amniotic fluid index (AFI) to assess long term adequacy of placental function and the chance to examine and evaluate Intrauterine growth had always been an interesting focus point for obstetricians and Nonstress test (NST) which is a screening test used in pregnancy to assess fetal status by means of fetal heart rate.It takes lesser time to perform(15 to 20 minutes)[(3)] compared to modified biophysical profile

The aim of the evaluation of fetal health during the antenatal period is to prevent intra uterine fetal demise or to avoid fetal complications due to asphyxia.

Doppler ultrasound is a non-invasive procedure that aims to evaluate blood flow in the vessels supplying the placenta and the foetus. The vessels which will be examined are umbilical artery and middle cerebral artery of the fetus.It is necessary for all high -risk pregnancies.

High-risk pregnancies increase the risks of maternal and fetal morbidity and mortality; and there is a need for appropriate investigation which can diagnose and provide opportunity for preventive interventions. In this new era of technological and medical advancements, earlier interventions are expected from obstetricians to improve maternal and perinatal outcomes

even before the complications set in pregnant women. Hence,We are conducting this study to compare Modified BPP (NST and amniotic fluid index) and Doppler findings in assessing the perinatal outcome in pregnancies.

OBJECTIVES OF STUDY

Primary objective:

To compare modified biophysical profile (MBPP)and Doppler flow velocimetry results in pregnant women for prediction of perinatal outcome in term high risk pregnancy.

Secondary objective:

To evaluate the association between the mode of delivery and abnormal Doppler and MBPP.

REVIEW OF LITERATURE

1.**Mehmet Bardakci** et al conducted a study in which the evaluation of the uterine and umbilical artery Doppler indices, routine examination, amniotic fluid index of 315 pregnant women were included. Both MBP and a non-stress test (NST) were conducted. The perinatal outcome was assessed using the non-reassuring foetal state (NRFS), perinatal mortality, 5-min APGAR score, and umbilical artery pH data. It was discovered that all indices produced negative results in groups with abnormal MBP and Doppler analyses. Additionally, it was discovered that MBP sensitivity was 60%, umbilical artery Doppler was 50%, and uterine artery Doppler was 30% when it came to predicting the non-reassuring foetal state (NRFS). The sensitivity increased to 70% when MBP and umbilical artery Doppler results were combined [(4)]

2.**RA Putri** et al conducted a retrospective study of 98 pregnancies with intra uterine growth restriction (IUGR)from January until December 2018 at Cipto Mangunkusumo Hospital Indonesia. After comparing with the standard, the Doppler parameters (cerebroplacental ratio) and adjusted biophysical profile's sensitivity, specificity, positive predictive values (PPV) and negative predictive values (NPV) were calculated. Modified biophysical profiles performed better in predicting newborn outcome than middle cerebral artery Doppler when absent end diastolic or reverse end diastolic of umbilical Doppler was additionally incorporated [(5)]

3. **Khushboo Malhotra** et conducted a cohort study on 150 high-risk pregnant women over 16 months. Doppler tests and adjusted biophysical profiles were performed on them. When the perinatal outcome was examined, it was discovered that individuals with both abnormal

MBBP and Doppler values and those with only aberrant MBPP had the highest rates of perinatal complications[6]

4.**Urvashi verma** ,**Ruchika garg** et al conducted a comparative study on 100 antenatal patients above 34 weeks.Following normal examinations and investigations, all patients underwent colour doppler and non-stress testing, and it was discovered by comparing the results of NST and Doppler that. Doppler demonstrated earlier changes than NST, giving it an average lead time of 5 days and a lead time of up to 8 days [7]

5. **Jankidevi S. Borade** et al conducted a study in which with a modified biophysical profile, 100 ANC patients with high risk factors underwent a 20-minute non-stress test (NST) and a 4-quadrant amniotic fluid index (AFI) evaluation. Data were run on each parameter. Results revealed that cases with abnormal MBPP had significantly higher rates of perinatal morbidity, intrapartum foetal distress, meconium-stained alcohol, APGAR score, requirement for neonatal resuscitation, and need for LSCS [8].

6. **William J Otto** et al conducted a study between June 1, 1995, and Nov. 1, 1996, in the Department of Obstetrics and Gynaecology, St. John's Mercy Medical Centre, Scottsdale, Arizona, group 1 included modified biophysical profile group and the other (group 2) modified biophysical profile plus measurement of the middle cerebral artery to umbilical artery systolic/diastolic ratio were randomly assigned to 665 individuals for prenatal surveillance. Neonatal outcome parameters, such as gestational age at delivery, birth weight, incidence of caesarean delivery for foetal distress, admission to the neonatal intensive care unit, days spent in the neonatal intensive care unit, and the presence of significant neonatal morbidity, were tabulated after patients were followed up serially. The results revealed no statistical difference in the outcome parameters between groups 1 and 2. However, group 2

patients had a significantly lower rate of caesarean sections performed due to foetal distress in a subgroup of patients examined for possible uteroplacental insufficiency [9].

7. **Kadir Bakay** et al, conducted a study between December 2009 and March 2010 in Istanbul Turkey on 99 patients. All patients enrolled in the study group underwent modified biophysical scoring and Doppler ultrasonography. The paediatrician recorded the baby's birthweight and APGAR ratings in the 1st and 5th minutes after delivery. The findings were reached. Modified biophysical profiles were discovered to be a more accurate diagnostic tool than Doppler analysis for predicting acute foetal distress and perinatal outcome. However, the results were improved when the modified bio-physical profile was combined with Doppler analysis [10].

8. **Dr. R.K. Talukdar** et al conducted a study in Gauhati Medical College and Hospital Guwahati, Assam, India from June 2018 to May 2019. The study involved 300 patients, who were split into two groups and monitored with Doppler and MBPP up to delivery. Women who were pregnant and had reached term (>37wks) were included in the study population. The Modified Biophysical Profile and UA & MCA Doppler were used to monitor the foetal development of all study participants who were pregnant. All of the women were monitored throughout their pregnancies. The combined Cerebroplacental ratio & MBPP has better sensitivity in postdated pregnancy to predict adverse perinatal outcome, according to research that looked at the Doppler & modified biophysical profile, rate of caesarean delivery in spontaneous & induced, Baby NICU admission & mortality, and rate of Doppler & modified biophysical profile [11].

9. **Manik Srivastava** et al conducted-on women with high-risk pregnancies who attended outpatient department of OBG at Rohilkhand Medical College & Hospital, Bareilly from Nov

2016 to Oct 2017. Within a week of delivery, a non-stress test was performed in Semifowler's position, and a semi-recumbent position Doppler ultrasound was performed. Umbilical artery pulsatility index, resistance index, S/D ratio, and cerebro-placental ratio were computed. According to the study's 100 patients, non-stress tests were normal in 74 cases and abnormal in 26, while Doppler results were normal in 67 cases and abnormal in 33. Doppler's sensitivity and specificity were 83.58% and 72.73%, compared to the non-stress test's 74.32% and 61.54%, respectively. It found that Doppler velocimetry was substantially more accurate than a non-stress test at predicting the perinatal outcome[12]

10. **OH Jensen** et al conducted a study in Aker University Hospital, Department of Obstetrics, on Ninety-four women with high-risk pregnancies. Doppler velocimetry and standard cardiotocography were used to monitor the patients. Doppler velocimetry is found to be more accurate than cardiotocography at detecting prenatal growth retardation, according to the study's findings [13].

11. **Dr. Archana Maurya** et al conducted a study on 110 admitted cases having one or more high risk factors which were admitted at Gajra Raja Medical College, Gwalior,M.P., India. Every patient underwent modified B.P.P. and C.T.G. These were the outcomes: The modified B.P.P. is a good predictor of foetal outcome, which significantly lowers perinatal mortality and morbidity. Sensitivity of the test (diagnostic accuracy) is improved in modified B.P.P. (79.5 as compared to 53.5 for N.S.T. and 60.5 for A.F.I., and P.P.V. (diagnostic power) is also improved in 85.83% as compared to 17.6% for N.S.T [14].

12. **Nishi Choudhury** et al conducted a study in 100 high risk patients at Central Referral Hospital (CRH), which is a teaching hospital of Sikkim Manipal Institute of Medical Sciences

(SMIMS) between November 2012 and April 2014 Patients were studied using Doppler velocimetry and the NST (non-stress test), and the results were compared to the perinatal outcome. The findings showed that newborn complications, NICU admissions, and perinatal fatalities were most common in patients with both NST and Doppler waveform abnormalities. Even patients whose NST results were normal but whose Doppler velocimetry results were abnormal had considerably more newborn problems. The group with abnormal NST and normal Doppler velocimetry, on the other hand, did not have any foetal compromise. Normal NST and normal Doppler velocimetry were found to predict foetal compromise with modest predictive values and did not significantly differ from one another. However, aberrant Doppler exhibited statistically significant (p value = 0.021) prognostic significance for identifying foetal impairment [(15).]

ANTEPARTUM SURVEILLANCE

The aim of the evaluation of fetal health during the antenatal period is to detect intra uterine fetal asphyxia, fetal growth restriction and fetal demise.

In this new era of technological and medical advancements, earlier interventions are expected from obstetricians to improve maternal and perinatal outcomes even before the complications set in pregnant women. Hence, we have conducted this study to compare Modified Biophysical Profile which includes Non-Stress Test and amniotic fluid index and Doppler findings in assessing the perinatal outcome in pregnancies.

Early detection and prompt intervention of the compromised foetus are key components of antepartum foetal surveillance. In addition to real-time ultrasound and umbilical artery Doppler velocimetry, antepartum foetal surveillance approaches based on evaluation of foetal heart rate (FHR) patterns have been utilised in clinical practice for almost four decades. Pregnancies complicated by pre-existing maternal diseases (such as diabetes mellitus) as well as those in which problems have arisen are frequently assessed for the risk of foetal death and fetal complication using antepartum foetal surveillance techniques

Various techniques exist for antepartum foetal surveillance, The optimal approach is one that seeks to identify the foetus that is at risk but is still in a healthy state and which needs immediate intervention. Some of the methods are listed here:

Fetal Activity Determination Test (FAD) (Fetal Kick Counts)

A well-oxygenated term fetus accelerates with 90% of movements [16]. (Women only feel ~ 30% of kicks) Cessation of fetal movements is correlated with fetal death.

Method:

Count same time each day

Report < 10 movements in 10 hr period for 2 consecutive days or no fetal movements in 10 hrs.<10 kicks in a 12-hour period.

Festal Movement Counting:

Woman should eat, drink, rest, and focus on fetal movement for 1 hour. Healthy fetus has 10 perceivable movements within 10 to 60 minutes. Recommend beginning at 28 weeks for at-risk women.↓ fetal movement is not necessarily ominous.

The modified biophysical profile (MBPP) is employed in the current study as the main surveillance test for high-risk pregnancies. Non-stress test (NST), a short-term indicator of foetal status, and amniotic fluid index (AFI), a long-term indicator of placental function, are the two parameters. Doppler ultrasound, a non-invasive technique, measures blood flow in the veins supplying the placenta and the foetus. The umbilical vein and middle cerebral artery of the foetus are the vessels that will be evaluated. All high-risk pregnancies require these test.

Amniotic fluid

Amniotic fluid offers a safe environment, protecting it from physical and biological harm and promoting growth and mobility.

Maternal morbidity, as well as perinatal morbidity and mortality, are both correlated with aberrant changes in amniotic fluid volume. Because it reflects the fetoplacental unit, the examination of the amniotic fluid volume is crucial for antenatal surveillance because it frequently serves as the earliest indication of an underlying foetal problem.

The important role of amniotic fluid is:

- Essential for the development of the musculoskeletal system and foetal mobility.

- Swallowing the fluid leading to gastrointestinal development.
- Prevents festal trauma
- Helps decrease risk of cord compression
- Bacteriostatic properties
- Prevents infection
- Fetal body temperature regulation

Production of amniotic fluid:

In first trimester and early second trimester, Amount is 5 -50 ml and arises from:

Ultrafiltrate of maternal plasma through the vascular uterine decidua (in early pregnancy).

Transudation of fetal plasma through the fetal skin and umbilical cord (up to 20 weeks of gestation) [17]. Fetal urine is a key component in the production of amniotic fluid during the second and third trimesters. The foetus starts producing urine at about 18 weeks gestation and increases steadily over the course of the pregnancy to about 7–17 ml each day. A foetus can produce 500 to 700 ml of urine per day when it is full-term, but after 40 weeks of gestation, its hourly urine production starts to fall. [18] At a rate of 60 to 100 ml per kg of foetal weight per day at term, foetal lungs also contribute to the volume of amniotic fluid.

Circulation of amniotic fluid: The amniotic cavity is a region that is metabolically active and a very dynamic location for fluid volume fluctuations.

Using sodium and deuterium oxide, Plentill (1966) illustrated the dynamics of amniotic fluid circulation [19]. The amount of amniotic fluid present at any given time reflects a fine balance between the structures that produce or permit fluid to enter the amniotic cavity, such as the

chorion frondosum, membranes, skin, urinary tract, and respiratory tract, and those that eliminate it, such as the gastrointestinal tract and amnio chorionic interface.

Other than the above there are two additional pathways intramembranous and trans membranous .The transfer of amniotic fluid and foetal blood that perfuses the umbilical cord, placental surface, and foetal skin is part of the more essential intramembranous pathway. The transmembranous pathway involves the interchange of maternal blood and amniotic fluid across the foetal membranes within the uterine wall[20]. At term, the amount of maternal blood and amniotic fluid exchanged is minimal and insignificant, whereas the daily intramembranous flow is close to 400ml. [21].

Removal- Amniotic fluid is primarily eliminated through the digestive system (by swallowing) and absorption into the foetal blood perfusing surface of the placenta.Up to 50% of the total volume of amniotic fluid is swallowed by the foetus at term.

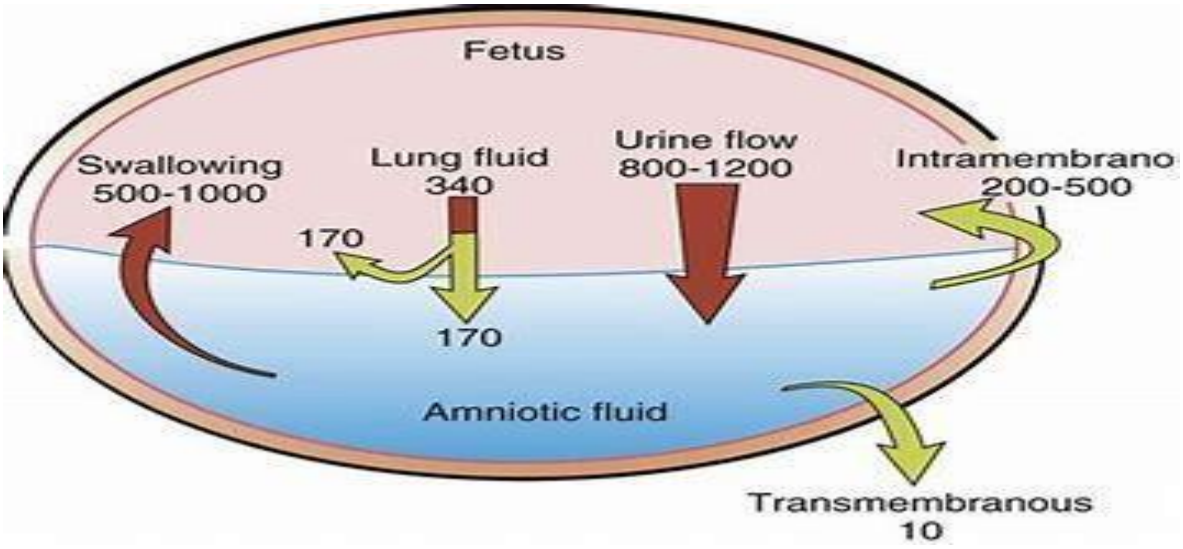


Figure 1 -Image showing circulation of amniotic fluid

AMNIOTIC FLUID CHARACTERISTICS

Physical characteristics of amniotic fluid include being clear yellow in colour and having a specific gravity between 1.0069 and 1.008.

CHEMICAL COMPOSITION: Changes with gestational age.

The large percentage (98–99%) of the amniotic fluid is water. Numerous dissolved and undissolved compounds, including foetal epithelial cells, are present in amniotic fluid, including urea, bile pigments, creatinine, fructose, glucose, renin, albumin, and globulin

AMNIOTIC FLUID: DISSOLVED SUBSTANCES

NUTRIENTS

Contents: Carbohydrates, peptides, and proteins, lactate, lipids, pyruvate, enzymes, electrolytes, and hormones are all present in amniotic fluid.

Taurine is the only amino acid found in greater concentration in amniotic fluid than in maternal and foetal blood. Amniotic fluid is rich in taurine. Other amino acids, however, are found in amniotic fluid at smaller amounts.

GROWTH FACTORS

The arginine present in amniotic fluid significantly aids in the development of the placenta and foetus.

Normally, ornithine, which is hydrolyzed from arginine, is converted into polyamines such spermine, spermidine, and putrescine.

The trophic mediators in amniotic fluid include :

1. Epidermal Growth Factor (EGF)

2. Transforming growth factor beta-1 (TGF-b1)

3. Granulocyte colony-stimulating factor (G-CSF)

4. Erythropoietin

Epidermal growth factor (EGF)- The midtrimester is when epidermal growth factor (EGF) reaches its peak.

When there is foetal growth restriction, this factor is greatly diminished. It is a growth facto r that is mostly prevalent in the amniotic fluid during the third trimester of pregnancy.

Transforming growth factor beta-1(TGF-b1)

This factor contributes to the intestinal epithelial cells' induction of terminal differentiation as well as the induction of cell migration, which speeds up the healing of intestinal injuries. Additionally, it increases IgA production.

Granulocyte colony-stimulating factor (G-CSF):

A cytokine that promotes white cell maturation, participates in the metabolism of pulmonary surfactant**.**

Erythropoietin:

Since the concentration of erythropoietin in amniotic fluid is proportionally correlated with the concentration of erythropoietin in umbilical cord blood, increased amniotic fluid erythropoietin is indicated as a diagnostic for chronic hypoxic condition of the foetus

IMMUNE FACTORS

Amniotic fluid and vernix both include a variety of substances that are immune system They are as follows:

1. Human beta-defensin

2.Alpha-Defensin (HNP1-3)

3.Lactoferrin (LF)[22]

PARTICULATE MATTER:

The term "echogenic amniotic fluid" refers to the presence of vernix caseosa or meconium during the third trimester [23]. Particulate particles in amniotic fluid have been discovered to be linked to a few congenital abnormalities.

These include

Foetal acrania

Harlequin Ichthyosis

Epidermolysis bullosa fetalis.

Volume of amniotic fluid:

Amniotic fluid volume: Weismann determined amniotic fluid volume at various gestational ages[24].

They discovered that amniotic fluid increased from around 1 ml at 7 weeks to 25 ml at 10 w eeks, 60 ml at 12 weeks, 400 ml at 20 weeks, and peaks at about one litre between 35 and 3 6 weeks.

The amniotic fluid content falls throughout the later stages of pregnancy and continues to d ecline after 40 weeks.

At 42, 43, and 44 weeks, the amniotic fluid volume is 480, 250, and 160 ml, respectively.

However, the pace of amniotic fluid loss in postterm pregnancies is variable; a sudden redu ction may happen within 24 hours.

According to research by Brace and Wolf, the volume of amniotic fluid increases gradually from 8 weeks of gestation until it reaches its statistical peak (variance analysis) at 32 weeks. These authors calculated the mean changes in amniotic fluid volume on weekly basis (based on polynomial regression equation).

Colour of amniotic fluid

Generally, in pregnancy the color of amniotic fluid is colorless**.** But due to exfoliative lanugo hair from fetus and also epidermal cells from fetal skin cells the color appears pale straw colored.

Abnormal color of amniotic fluid

Golden yellow-RH Incompatibility

Green – Meconium-stained liquor

Greenish yellow- Post maturity

Tobacco red (dark brown) – Intra uterine death

Dark colored – concealed hemorrhage

Abnormalities of amniotic fluid volume:

- Oligohydramnios
- Polyhydramnios

Oligohydramnios:

Oligohydramnios is the reduction in quantity of amniotic fluid and defined as is defined as amniotic fluid index less than 5 cm and SVP <2.

Causes:

- Pregnancy induced hypertension
- Post term pregnancy
- Premature rupture of membranes
- Intrauterine growth restriction (IUGR)
- Chronic abruption
- Leaking fluid following amniocentesis or chorionic villus sampling.
- Usage of drugs by mother like prostaglandin inhibitors, angiotensin converting enzyme inhibitors and non-steroidal anti-inflammatory drugs
    - Bilateral multicystic dysplastic kidneys and urethral blockage are among the foetal renal abnormalities.
    - Triploidy, thanatophoric dwarfism, thyroid gland dysfunction, skeletal dysplasias, congenital heart block, and numerous anomalies are examples of non-renal foetal abnormalities.

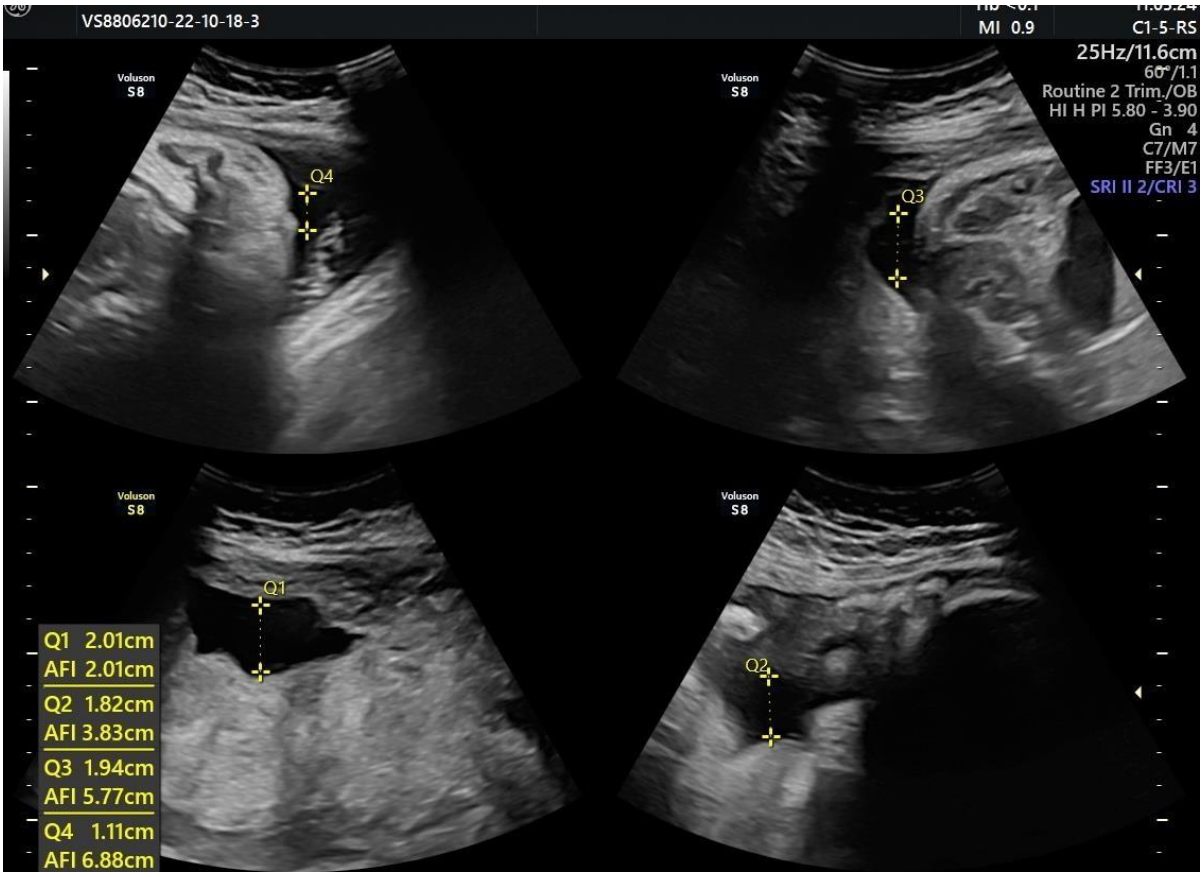


Figure –2 – Image showing AFI 6.88 cm indicating oligohydramnios

Polyhydramnios:

Definition: Excess amount of amniotic fluid, quantitatively it is diagnosed when SVP > 8cms and AFI > 25 cms.

Causes:

- Maternal causes are Rh isoimmunization, Diabetes mellitus and syphilis.
- Fetal causes are Multiple pregnancy and Fetal anomalies like central nervous system anomalies, gastrointestinal anomalies, genitourinary anomalies, skeletal malformations, fetal tumors, cardiac anomalies, chromosomal defects, genetic syndromes, hematologic disorders and fetal infections.
- Placental causes are placental chorioangioma and circumvallate placenta syndrome.
- Idiopathic – in 66% of the cases the cause is unable to be diagnosed .

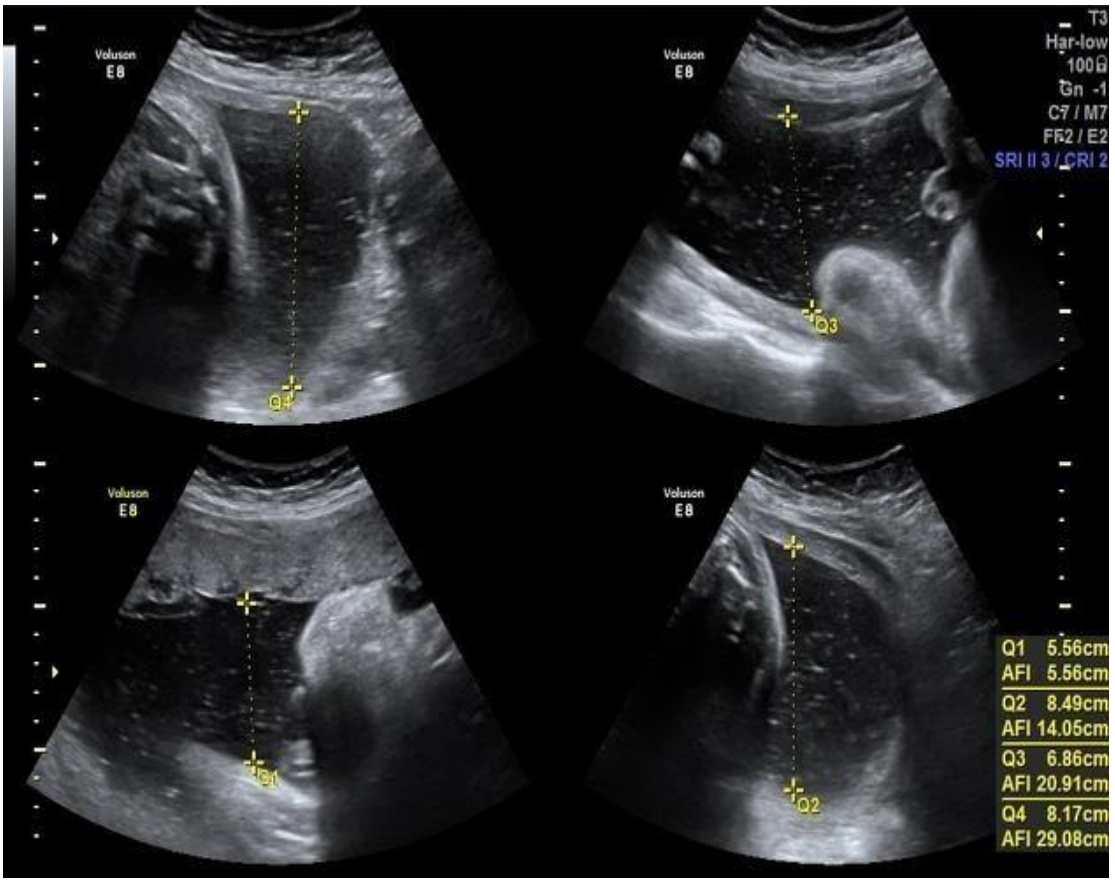


Figure 3 - showing AFI 29.08 cm hence indicating polyhydramnios

Methods to assess amniotic fluids:

Prior to the invention of ultrasound, AFV was evaluated by palpating the abdomen, measuring the symphysio fundal height, and measuring the abdominal circumference. Several sonographic methods of amniotic fluid assessment have been employed because ultrasonography makes it possible to see the foetus and its surroundings.

Both a subjective assessment and a semi-quantitative method can be used to evaluate ultrasound measurements of amniotic fluid**.**

1.Subjective assessment

2. Semiquantitative measurement

- Amniotic fluid index
- Single maximum vertical pocket

3.Quantitative measurement

Subjective assessment

In this method, the relative amount of echo-free areas is compared to the space occupied by the fetus itself. Although this method is simple and rapid, it requires a highly trained observer and lack of a numerical result for comparison are important disadvantages. However, one may decide to employ the amniotic fluid index to corroborate the subjective sense in cases when a decreased or increased quantity of amniotic fluid volume is suspected.

Semiquantitative methods include single maximal vertical pocket (SVP), the two-diameter pocket technique and the amniotic fluid index (AFI)

Quantitative measurement – it is done via amniocentesis by dye dilution techniques using para – amino Hippurate [(24)]

The dye-dilution technique is limited because the procedure is invasive, time consuming and requires laboratory support while the direct measurements can only confirm the volume at delivery and cannot be used to predict the amount of amniotic fluid prior to birth.

SINGLE DEEPEST VERTICAL POCKET

In the Single Vertical Pocket technique, the deepest vertical pool is found, and the transducer is then positioned perpendicular to the uterine contour. The amniotic pool's maximal vertical diameter is measured without the cord and the foetal parts. It's crucial that the horizontal portion of the pocket measures more than 1 cm at this level.

The SVP is to be interpreted as follows [25]:

Oligohydramnios: depth of less than 2 cm;

Normal: depth of between 2 and 8 cm

Polyhydramnios—depth of 8 cm or more

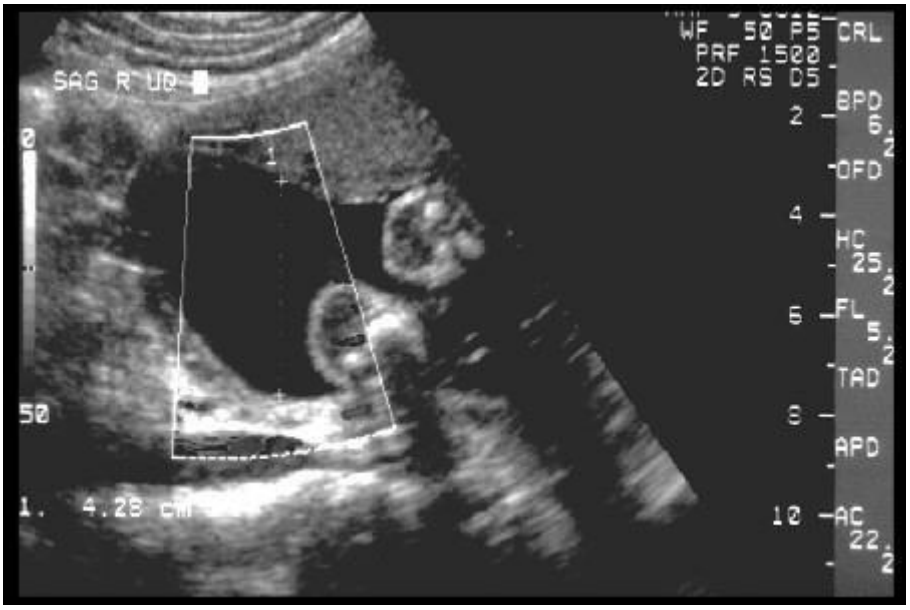


FIGURE 4 – Ultrasound image showing measurement of SVP

AMNIOTIC FLUID INDEX(AFI)

Rutherford and Phelan proposed AFI. The amniotic fluid index is a standardised method for determining whether there is sufficient amniotic fluid throughout pregnancy. When a patient is at least 24 weeks pregnant, the amniotic fluid index is employed.The amount of amniotic fluid seen during an ultrasound of a pregnant uterus is measured by the AFI score, which is expressed in centimetres.The amniotic fluid index is a standardised method of determining whether there is sufficient amniotic fluid during pregnancy.

Procedure for measuring AFI

- The patient's position should be supine for an ultrasonography examination. Knees bowed and tilted slightly to the left will make the patient more comfortable.
- You can employ a linear, curved, or transducer (Convex 3.5 MHz)
- The umbilicus is suggested by some authors as the dividing line. But if the gestation is under 28 weeks, it is improper. Using the maternal sagittal midline and an arbitrary transverse line, divide the uterus into four quadrants that are roughly midway between the symphysis pubis and top margin of the uterine fundus.
- The transducer must be kept perpendicular to the coronal plane of the mother and parallel to her sagittal plane. • The vertical depths of the unobstructed and clear pocket of the AF are visualized; nevertheless, medial tilting of the transducer may result in unintentional measurement of the neighboring quadrant.
- The ultrasonic callipers are used to measure this pocket absolutely vertically. Umbilical cord pockets could result in an overestimation of the AFV during measurement. The procedure is performed in each of the four quadrants, and the AFI is calculated by adding the pocket measurements.

- Run the four-quadrant evaluation three times and average the results if AFI is less than 8 cm. By doing measurements in triplicate, oligohydramnios lowers interobserver error.

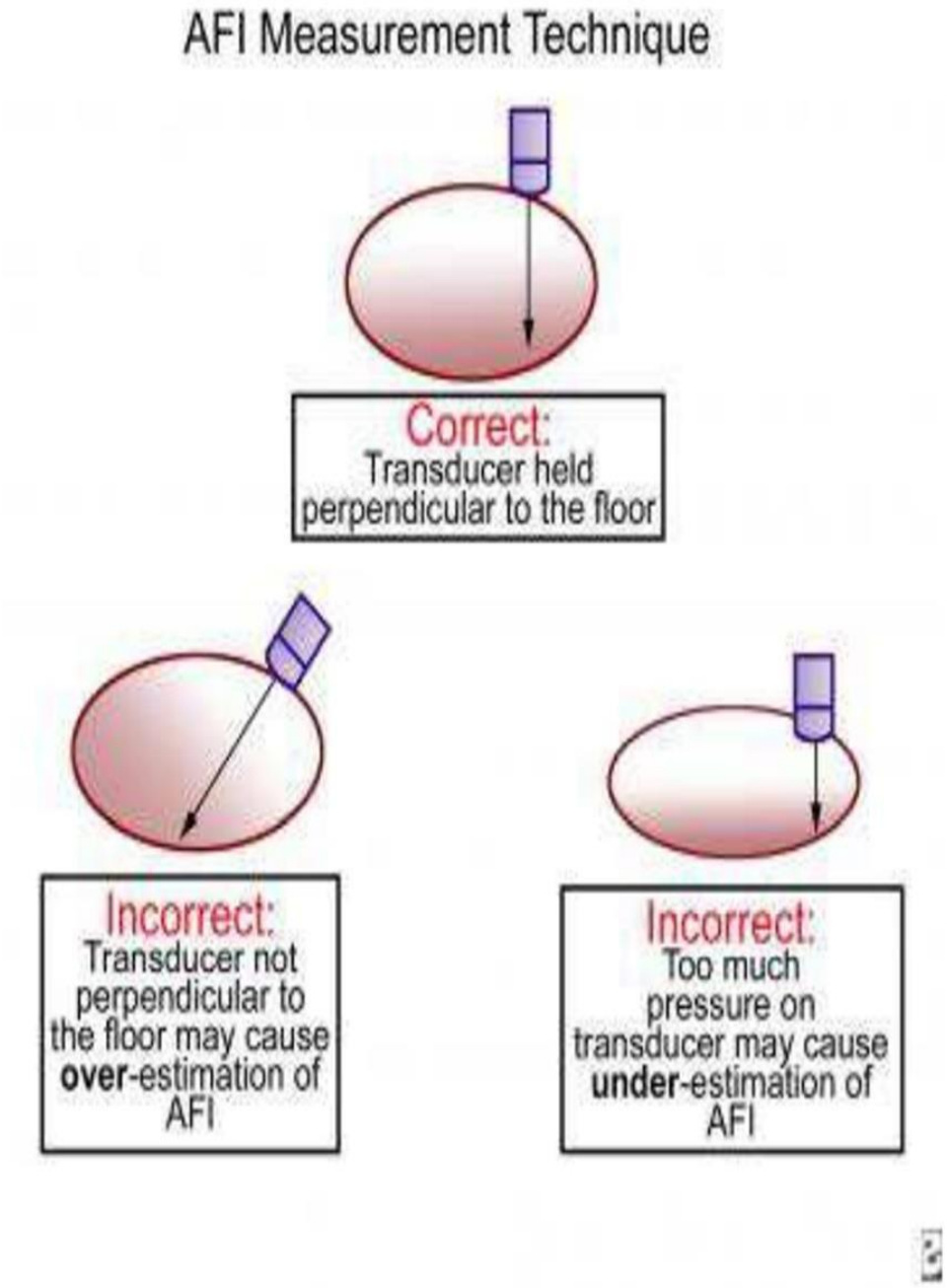


Figure 5 – Correct method to place transducer to measure AFI

Pitfalls in AFV assessment due to wrong techniques:

• Underestimation of AFI and SDP results from excessive pressure on the maternal abdominal transducer.

• Artifactual echoes may cause AFI and SDP to be underestimated (especially in obese patients).

• Underestimation of AFI and SDP due to free-floating particles in the third trimester.

• Overestimation of AFI and SDP results from measuring pockets in the biggest non-perpendicular diameter.

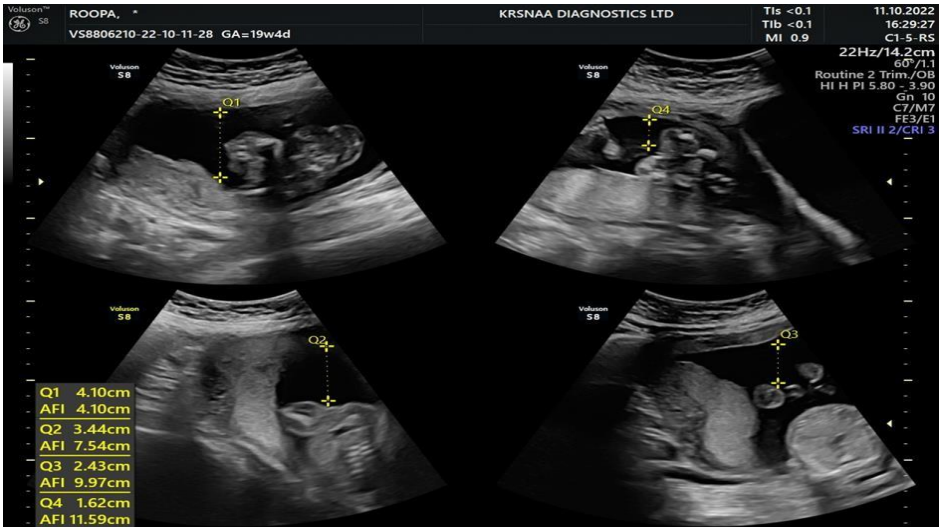


Figure 6 – Ultrasound image showing measurement of 4 pockets to measure AFI

The interpretation of AFI [26]

- Oligohydramnios is considered when AFI 5 cm or less
- Normal: AFI > 8 cm and 20 cm
- Polyhydramnios: AFI more than 24 cm
- Borderline oligohydramnios are those with an AFI of 5.1 to 8 cm, while borderline polyhydramnios are those with an AFI of 21 to 23 cm.

TWO DIAMETER POCKET TECHNIQUE: This technique involves measuring and multiplying the vertical and horizontal diameter of a pocket which is devoid of cord or fetal parts. The interpretation of this is as follows[27]

• Oligohydramnios: less than 15 cm

• Normal: 15.1 to 50 cm

• Polyhydramnios: more than 50 cm

Amniotic fluid volume assessment in pregnancy evaluation is helpful in prediction of IUGR and placental insufficiency and poor perinatal outcome.

Oligohydramnios is often a sign of poor placental function [28]. Because fetal urinary flow is determined in part by the state of fetal hydration, which in turn is determined by placental function. Oligohydramnios is frequently associated with fetal growth restriction, intrapartum asphyxia and fetal death [29].

• AFI > 5 cms with reactive NST: 1 in 1000 foetal deaths per week.

• Within 4 days, patients with mild oligohydramnios (AFI 5-8cms) may suffer significant oligohydramnios.

• Patients with borderline AFI have a greater incidence of IUGR and require more thorough antenatal care as a result.

• An indication of twice-weekly antepartum testing and the necessity for more intense antenatal surveillance is AFI of 5 to 8 cm (borderline AFI).

Prediction of poor perinatal outcome:

Low APGAR scores and a greater frequency of LSCS for foetal distress are linked to antepartum and intrapartum AFI of less than 5 cm [30].

Perinatal morbidity and mortality rates are higher in pregnancies complicated by extremes of AFV.

Excessive amniotic fluid is linked to postpartum hemorrhage, abruption of the placenta, incorrect foetal presentation, and surgical delivery during labor.

Depressed APGAR scores, meconium passage, abnormalities of the FHR, and oligohydramnios are also common findings.

NORMAL AFI PERCENTILES ACCORDING TO GESTATIONAL WEEKS

Direct volumetric methods, indicator dilution techniques, and more recently, quantitative amniotic fluid via ultrasonographic methods, have all been used to measure amniotic fluid volumes at various gestational ages.AFV gradually rises throughout pregnancy, peaking at around 32 weeks.The mean AFV remains largely consistent between weeks 32 and 39, falling between 700 and 800ml.The AFV gradually decreases from 40 to 44 weeks at a rate

TABLE 1- Normal AFI percentiles according to gestational age measured in cms.

GA	3rd	5th	50th	95th	97th
18	8.95	9.49	15.03	20.57	21.34
19	8.67	9.22	14.87	20.53	21.32
20	8.39	8.95	14.72	20.49	21.30
21	8.12	8.68	14.57	20.45	21.27
22	7.84	8.41	14.41	20.41	21.25
23	7.56	8.15	14.26	20.38	21.23
24	7.28	7.88	14.11	20.34	21.21
25	7.00	7.61	13.96	20.30	21.19
26	6.72	7.34	13.80	20.26	21.16
27	6.44	7.07	13.65	20.22	21.14
28	6.16	6.81	13.50	20.19	21.12
29	5.88	6.54	13.34	20.15	21.10
30	5.60	6.27	13.19	20.11	21.08
31	5.33	6.00	13.04	20.07	21.05
32	5.05	5.73	12.88	20.03	21.03
33	4.77	5.47	12.73	20.00	21.01
34	4.49	5.20	12.58	19.96	20.99
35	4.21	4.93	12.43	19.92	20.97
36	3.93	4.66	12.27	19.88	20.94
37	3.65	4.39	12.12	19.84	20.92
38	3.37	4.13	11.97	19.81	20.90

GA=gestational age.

THE NON-STRESS TEST

"The foetus can be regarded as safe," observed Hammacher, especially if reflex movements are accompanied by an obvious increase in the amplitude of oscillations and in the baseline foetal heart rate [31]. This served as the foundation behind the NST and its relationship to FHR accelerations and foetal health.

Ten years later, NST was first introduced by Lee and colleagues [32], and Rochard [33] and colleagues then developed clinical testing protocols based on resting FHR tracings.

According to the American College of Obstetricians and Gynecologists' (ACOG) most recent definition, there must be two or more accelerations that peak at 15 beats per minute or more, continue at least 15 seconds each, and occur within 20 minutes of the test's commencement**.**

PRINCIPLE

Non-stress test is based on the principle that, a well oxygenated fetus responds to spontaneous or induced movements with fetal heart accelerations.This indirectly indicates a normally functioning autonomic nervous system and excludes cellular hypoxia

Method of performing NST

NST is non-invasive, simple to use, and easy to interpret. The patient readily accepts it.

• Assume a semi-Fowler posture for the patient.

• Place pillows beneath one hip to shift the uterus' weight away from the inferior vena cava.

• Place the tococardiographic apparatus on the mother's abdomen, and for 10 minutes, monitor the FHR and uterine activity.

• Explain to the patient to press the uterine contraction tracing's calibration button each time she detects foetal movements.

• A reactive trace is present when two or more FHR accelerations of 15 or more each are clearly recorded over a 20-minute period.

PATHOPHYSIOLOGY OF FHR AND CTG

Furthermore, the baseline variability seen on the CTG trace is the result of the continual oscillation between the sympathetic and parasympathetic nervous systems, which defines the baseline's "bandwidth."

The appearance of accelerations on the CTG trace is explained by the somatic nervous system, which also controls voluntary control of bodily movements through skeletal muscles [(34)]. Accelerations, on the other hand, can occasionally be observed in anaesthetized foetuses, suggesting that somatic nervous system activity may also be centrally mediated.

A foetus will have to employ every resource at his or her disposal to adjust to the continuously changing and fast accelerating intrauterine environment during labour, which is the most stressful experience of the fetus's whole life.Each foetus has a distinct physiological reserve that can be altered by a combination of antenatal (such as pre- or post-maturity intrauterine growth restriction) and intrapartum risk factors (such as infection or meconium and usage of oxytocin to hasten labour, for example).

Parasympathetic Nervous System

Activities that take place while the body is at rest are controlled by the parasympathetic nervous system (such as listening to calm music, performing yoga) [(35)]. The "fight or flight"

reaction, on the other hand, is brought on by the sympathetic nervous system and is vital for survival.

In reaction to any hypoxic stress, the parasympathetic nervous system will make an effort to lower the FHR in order to maintain a positive energy balance in the foetal heart. This is due to the fact that, unlike adults, a foetus cannot rapidly improve the oxygenation to its heart by increasing the respiratory rate while it is submerged in a pool of amniotic fluid. Baroreceptors and chemoreceptors are two classes of receptors that mediate parasympathetic activity [36].Baroreceptors, the carotid sinus and the arch of the aorta both include these stretch receptors. Both the foetal head and the umbilical cord may experience repeated compressions during labour as a result of the commencement and progression of uterine contractions.

The blockage of the umbilical artery increases peripheral resistance, which raises foetal systemic blood pressure and stimulates these baroreceptors in the carotid sinus and aortic arch.

The cardiac inhibitory (parasympathetic) centre in the brain stem would receive impulses from the baroreceptors after they were triggered. As a result, the heart's atrioventricular node is inhibited, causing the heartbeat to slow down through the vagus nerve.

Additionally, baroreceptor activation lessens the heart's sympathetic activity.

Such "baroreceptor-mediated" decelerations will appear as variable decelerations due to umbilical cord compression on the CTG trace. These are typically brief periods caused by uterine contractions, the foetal heart quickly recovers to normal, and the foetus is not injured by hypoxia as a result.

Therefore, early (head compression causing stimulation of the dura mater, which is richly supplied by the parasympathetic nerves) or typical variable decelerations should be viewed as

pure "mechanical stresses" during labour in the absence of other abnormalities on the CTG trace (unstable baseline or changes in baseline variability).

Therefore, other than continued observation, they don't need any interventions. These are located centrally within the brain and peripherally on the aorta and carotid bodies. Changes in the biochemical makeup of the blood—increased hydrogen ion and carbon dioxide buildup, as well as reduced oxygen partial pressure—stimulate chemoreceptors.These receptors become active during labour, stimulating the parasympathetic nervous system and lowering the FHR. However, when chemoreceptors are triggered, it takes longer to return to the initial baseline heart rate, in contrast to the short-lasting decelerations mediated by baroreceptors.

Decelerations that result from the stimulation of baroreceptors will therefore be related to the compression of the umbilical cord, they will have a rapid drop, and rebound quickly.

Interpretation of Non-Stress Test:

The four key elements are as follows: [37-40]

I. Base line fetal heart rate

II. foetal heart rate variability

III. foetal heart rate accelerations

IV. foetal heart rate decelerations

Base line fetal heart rate: It is the average foetal heart rate in intervals of 5 beats per minute lasting no less than 2 minutes throughout a 10-minute period.

Normal baseline FHR at different stages of gestation, from 12 to 30 weeks: 140 to 180 beats per minute, 30 to 40 weeks: 110 to 160 beats per minute, 40 weeks later: Normal heart rate is 110 beats per minute.

110 to 160 beats per minute is considered to be normal.

Tachycardia - More than 160 beats per minute

Bradycardia – Less than 110 beats per minute

1. Base line abnormalities:

A] **Tachycardia-**Base line in tachycardia refers to a sustained increase in FHR to above 160 beats per minute, which can only be determined after observing for at least 10 minutes.

Causes:

1. Maternal stress, for instance, can be eased by analgesia when there is acute pain.

2. Fetal hypoxia: Baseline tachycardia has been demonstrated to be the initial clinical indicator of foetal distress on auscultation.

The foetus tends to increase its heart rate in order to maintain adequate cardiac output because it has a restricted ability to increase stroke volume.

3. Disease: Tachycardia is brought on by maternal and foetal illnesses.

4.epidural analgesia

5. Preterm infants

6. Drugs like beta-adrenergic ones

7.Maternal and fetal anaemia

8.Maternal Cardiac Failure

The likelihood of acidosis is higher when tachycardia is accompanied by additional symptoms including loss of baseline variability, deceleration, etc. Most frequently, late deceleration is related to prenatal hypoxia and foetal tachycardia.

Bradycardia: Fetal heart rate decreases to < 110 beats per minute after at least 10 minutes of recording.

Causes:

- Foetal Hypoxemia: When PO2 levels decrease, chemo receptors are activated.
- Tissue hypoxia - Bradycardia, slowed heartbeat, and decreased baseline variability are found.
- Tissue hypoxia -Bradycardia, slowed heartbeat, and decreased baseline variability are found.
- Local anaesthetics
- drug abuse
- Partial cord compression - This occurs most frequently in Oligohydramnios and is characterised by baseline bradycardia as a result of the cord becoming entrapped between the foetal limbs. The patient feels relieved when it turns from one side to the other.
- Post-dated pregnancy
- Head compression - Most frequently observed in the transverse and posterior occipital positions.
- Prenatal heart block

These situations point to the necessity of ongoing foetal monitoring and assessment.

The problem might be resolved by taking easy steps like placing the woman on her side, giving her oxygen, stopping the use of oxytocin, poor contact of the transducer, and treating her maternal hypotension.Depending on the pattern, it is preferable to think about having the foetus delivered if there is still no improvement. Before making a choice, the foetal scalp simulation test may be carried out if there is an indeterminate foetal heart rate pattern.

Reasons for the changes in Base Line variability:

A. Fetal Hypoxia

B. Fetal acidosis

C. Prematurity

D. Fetal sleep

E. Local Anaesthetic Drugs

F. Fetal CNS abnormality

G. Fetal heart malformation

Flat CTG: (reduced variability)

It is seen in fetal hypoxia or prolonged fetal sleep

- Sleep phase of baby
- Depressants e.g opiates
- Thumb sucking
- Maternal dehydration

IMPORTANCE

The baseline variability indicates the integrity of ANS. In spite of the other characteristics of the trace/FHR pattern, baseline variability is a good indicator of foetal health and when it is seen in the final 20 minutes before delivery, newborns were in good condition.

According to research, there is no chance of foetal acidosis when baseline variability is normal. Episodes of reduced variability that typically last up to 40 minutes are linked to quiet sleep.

However, it must run for at least 40 minutes without two accelerations being detected in any 20-minute period in order to be considered non-reactive. Good variability and accelerations are linked to active motions.

A reactive trace is defined as two accelerations occurring within a 20-minute time span and is indicative of a healthy foetus.

2.BEAT-TO-BEAT VARIABILITY

It is the range of the baseline variation, ignoring accelerations and decelerations, over a given bandwidth. It displays how the parasympathetic and sympathetic nervous systems interact. The primary indicators of developing acidosis and hypoxia are changes in baseline variability and rate.

METHOD-Drawing horizontal lines at the highest point of the peak and lowest point of the troughs of the heightens of the trace in a 3 cm segment (for paper speed of 3cm/min) provides the baseline variability (normal - 10 to 25 beats/minute).

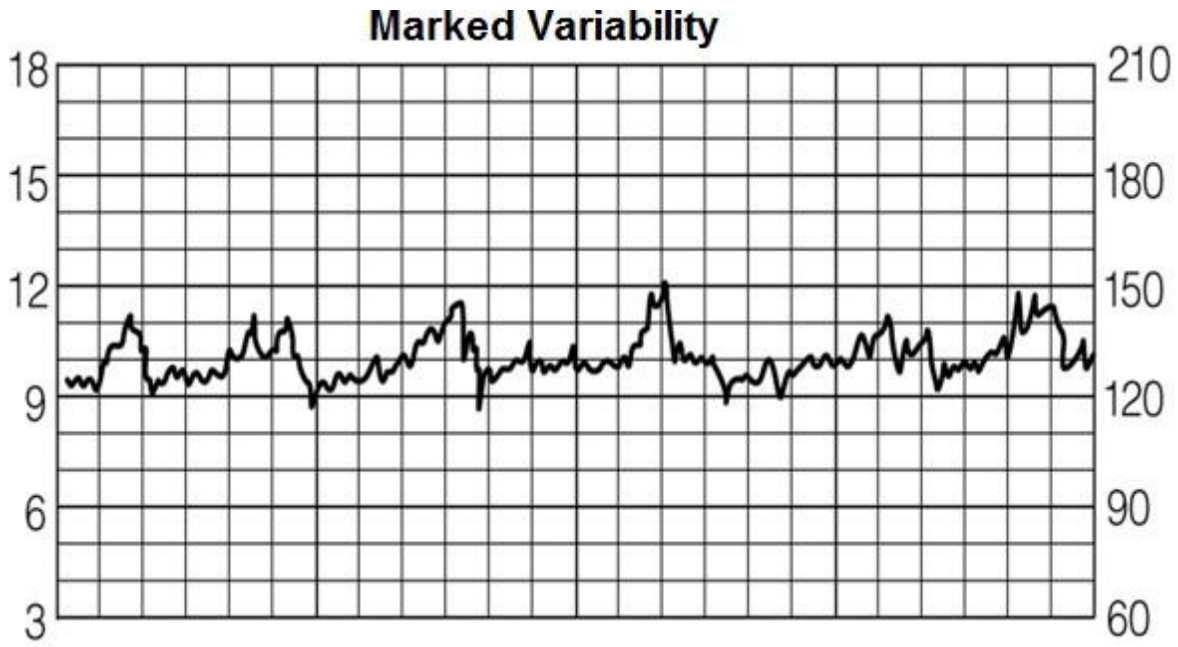


FIGURE 7 – NST SHOWING MARKED VARIABILITY

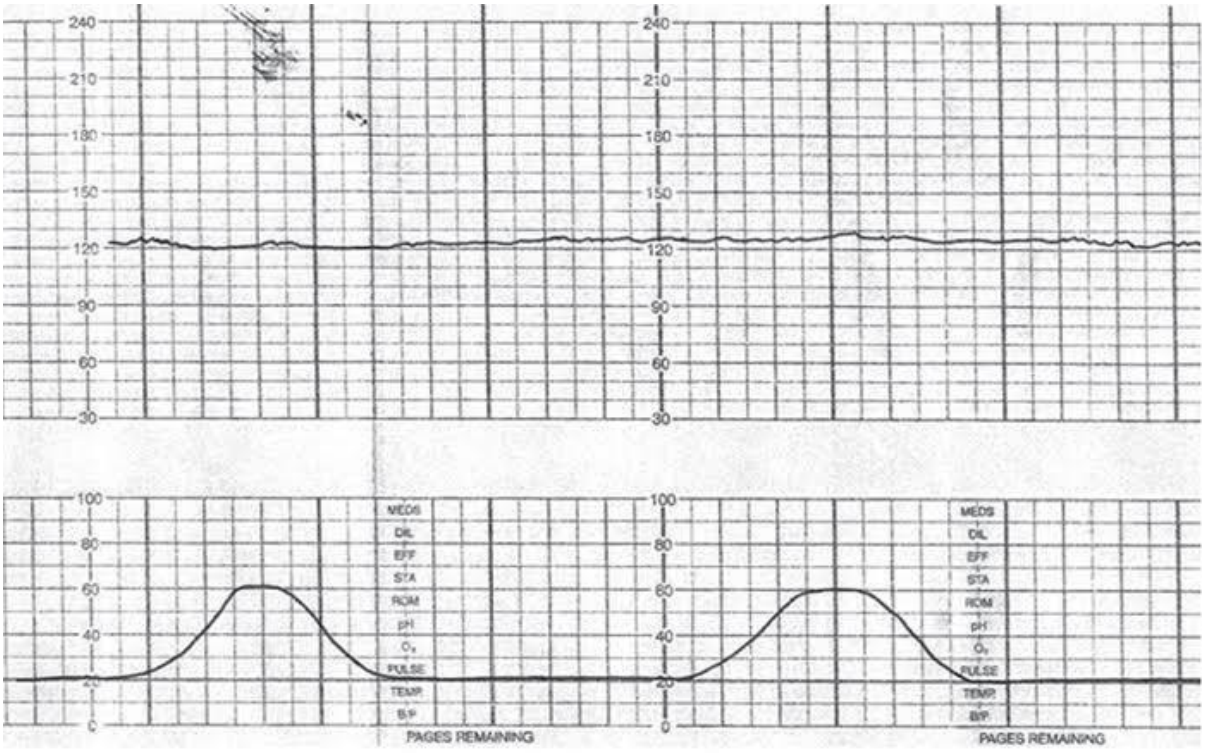


FIGURE 8 – NST SHOWING ABSENT VARIABILITY

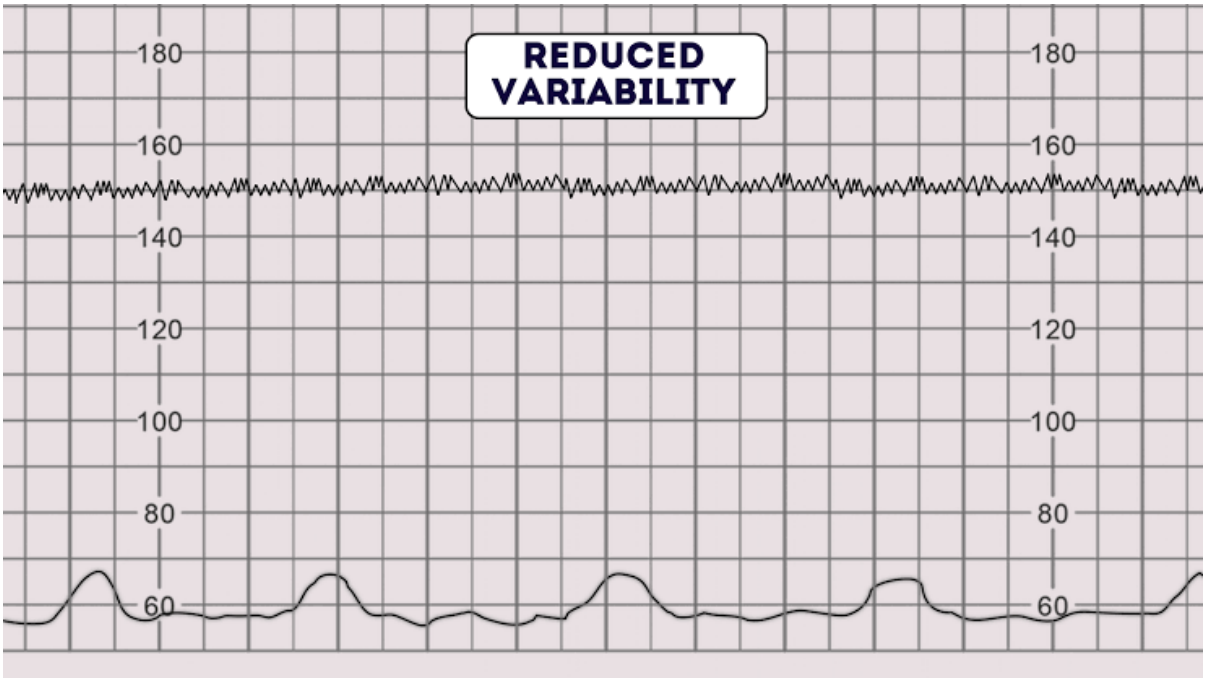


FIGURE 9 – NST SHOWING REDUCED VARIABILITY

INTEPRETATION

Normal beat-to-beat variability ranges from 10-25 beats/minute.

- Absent variability- beat to beat variability of less than < 5 beats/minute

  variability.

- Short-term variability-5-10 beats/minute is a reduced beat-to-beat variability.

- Long-term variability-25 beats/minute is an increased beat-to-beat variability**.**

Decelerations

These are foetal heart rate drops that last at least 15 seconds and drop by at least 15 beats from the baseline (Ingemarson et al 1993) [41]

Deceleration-related beat losses should also be taken into consideration. Both in the early third trimester and in IUGR, shallow late decelerations can be detected. Cord compression results in a varied deceleration that is harsh and abrupt.

Variable deceleration

A sudden, visually apparent reduction in FHR that may or may not be connected to contractions and can vary in onset, depth, and duration. The FHR drops by at least 15 bpm, for at least 15 seconds, and for no longer than 2 minutes. Blood flow disturbances in the umbilical cord are the cause of these. They are frequently linked to an absence of or reversal of the umbilical artery's end diastolic flow. The sequence of events was characterised by Steer in 1986 in terms of varying deceleration.

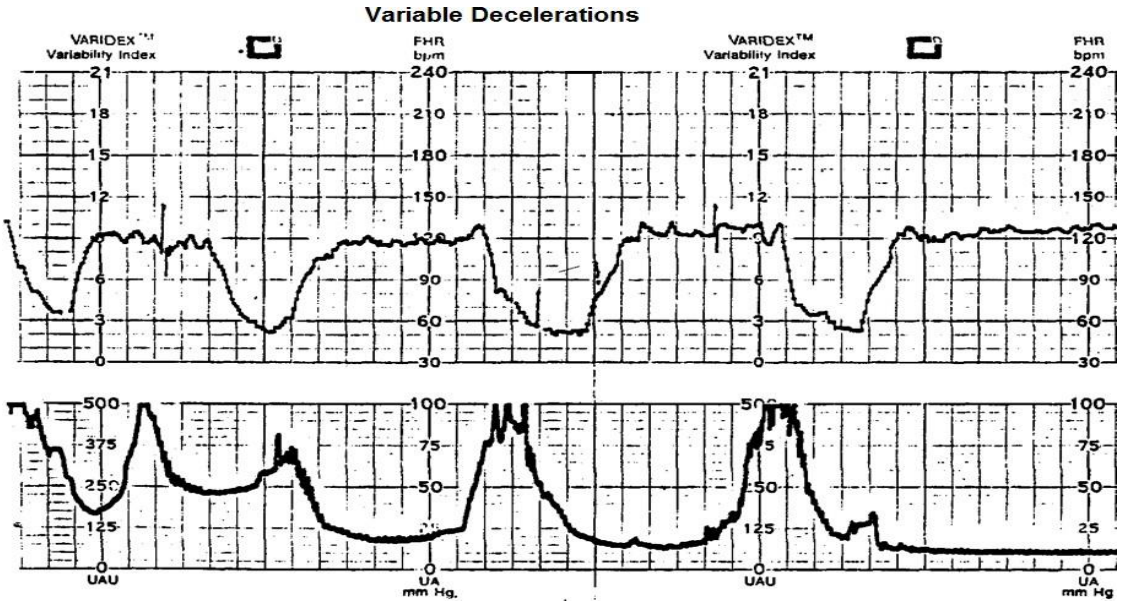


FIGURE 10-NST showing variable decelerations

Early events: There is a compensatory response and venous flow obstruction alone.

Later events: There is severe cord compression in this case leading to obstruction in arterial blood flow. The remaining mechanisms, where variability is still maintained, are foetal head compression and head descent via the birth canal.

Factors associated variable deceleration:

1. Short cord

2. Oligohydramnios

3. Deficient Wharton's jelly

4. Breech presentation

5. Occipito posterior position

6. face presentation.

Prognosis of variable deceleration:

The choice must be made in consideration of the following factors.

Hypoxia is likely to occur if the deceleration happens repeatedly soon. The danger of hypoxia increases with a longer time.

Compared to U-shaped dips, V-shaped dips are almost completely risk-free. Absence of acidosis is indicated by the initial acceleration.

Rebound tachycardia is a sign of hypoxia when it is present. Flattening of the base line fluctuation also implies a poor prognosis.

Management of variable deceleration

- Changing the maternal position

- oxygen inhalation
- continuous monitoring
- analysis of tracing
- tocolysis and amnio infusion.

Early decelerations are called as synchronous or reflex deceleration, reason being vagal stimulation**.**

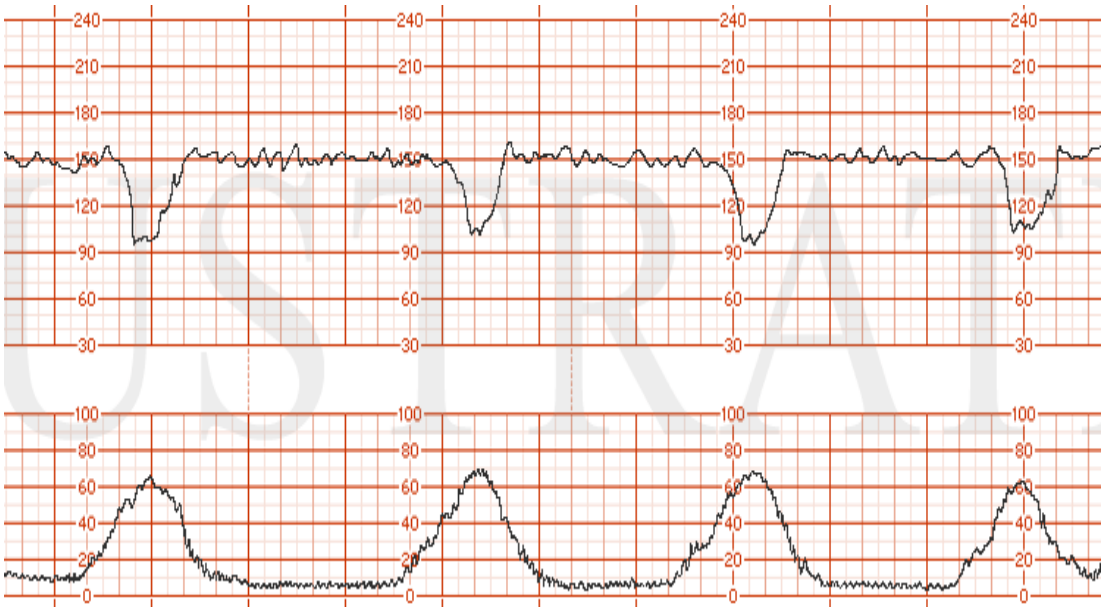


FIGURE 11 - NST showing early decelerations.

Features: V-shaped dip with peak uterine contraction at its apex. It starts right as the contraction starts and ends when it ends. It is brief, and baseline FHR and variability are consistent with normal intervals between contractions.

Causes: Compression of the head during the second stage of labour and partial compression of the cord.

Significance: Uncomplicated early deceleration does not indicate acidosis or hypoxia. Thus, it is preferable to wait and carefully watch because there has been a significant reduction in cardiac output, which might result in hypoxia and acidosis. (Steer 1996)

Management: In order to evaluate the status of the labour and rule out cord prolapse and any obstruction.

Late deceleration: FHR often decreases and then returns symmetrically with uterine contractions.

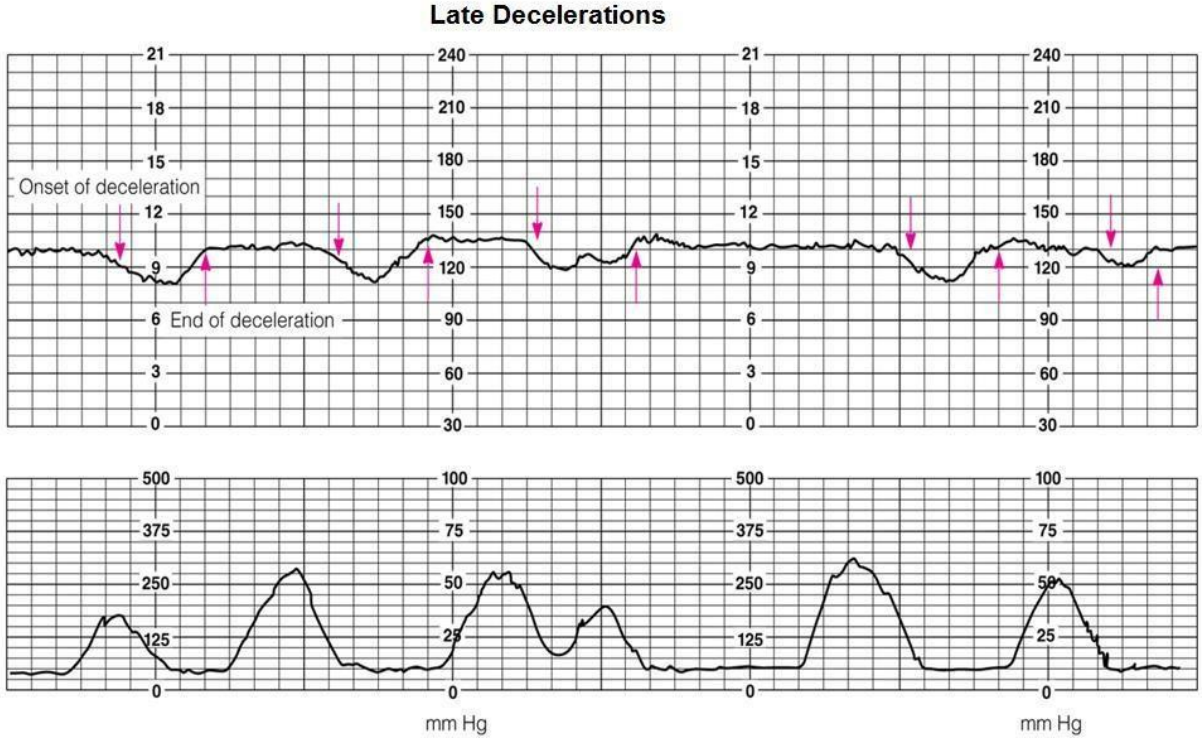


FIGURE 12– NST showing Late Decelerations

The nadir of the deceleration occurs after the apex of contraction, indicating a delayed timing of the deceleration.

The commencement, nadir, and recovery of deceleration often happen after the contraction's peak, finish, and beginning, respectively.

Late decelerations are interrelated with the following conditions:

1. Duration of contractions
2. Amplitude
3. pO2 of fetal blood
4. pH of fetal blood.

Prognosis: When the base line heart rate and variability are preserved, the compromise is mild.

Causes of late decelerations

Epidural block, maternal hypotension, severe anemia.

Uterine causes: Seen in Oxytocin or prostaglandin induction

Management of late deceleration- In this circumstance, it is advised to turn the patient on her side while withholding stimulants, perform tocolysis, administer oxygen, treat hypovolemia, treat dehydration, and treat placental insufficiency.

When a problem has a direct external cause, the foetus is not harmed or complicated, the underlying cause is identified and treated, variability is retained, and the baseline FHR is kept. Since the baseline foetal heart rate and variability fluctuate when the foetus is already impacted, it is advisable to act straight away.

Prolonged deceleration: This is a decrease in FHR from the baseline, which is defined as 15 beats per minute or more lasting 2 minutes or more but less than 10 minutes in duration.

Accelerations

A foetal heart rate spike that is immediately visible and abrupt (peak to trough in less than 30 seconds). At 32 weeks of pregnancy and beyond, an acceleration has a peak heart rate of 15 beats per minute or more and lasts for at least 15 seconds but less than 2 minutes before returning to the baseline.

Before 32 weeks of pregnancy, an acceleration has a peak heart rate that is 10 beats per minute or more above the baseline, lasts at least 10 seconds, but returns in less than 2 minutes**.**

Causes: Fetal movement, uterine contractions, fetal stimulation ([42,43])

Significance of accelerations

When accelerations were present, foetal acidity was discovered to be nil (Beard et al 1971). If accelerations were observed even in the presence of unusual or suspicious evidence and were brought on by external stimuli, the foetus was not acidotic.

Conclusion-

Acceleration is a sign that the foetus is healthy. However, the absence of accelerations is not invariably a sign of foetal impairment. In these situations, a decision should be made after additional observation.

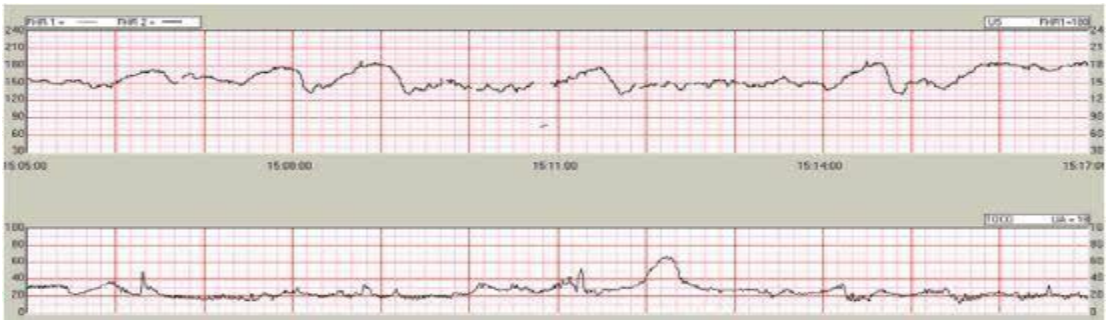


FIGURE 13 – Image showing reactive NST

Sinusoidal pattern: Visually noticeable, smooth, sine wave-like undulating pattern in FHR base line that lasts for at least 20 minutes and has a cycle frequency of 3 to 5.

Fetal anaemia is an example of this. There could occasionally be a mix of various decelerations.The term for this is combined deceleration.

. It can be: -

i) Early + late deceleration

ii) Variable + Late deceleration

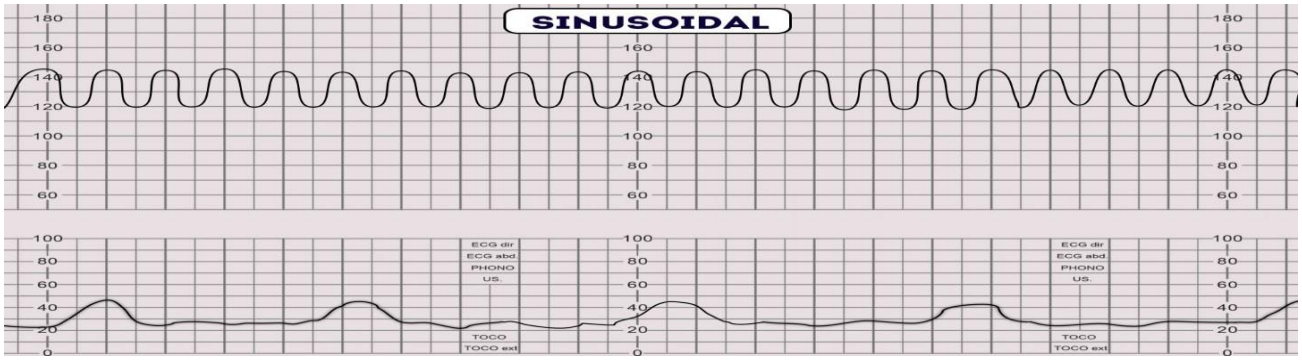


FIGURE 14– NST showing sinusoidal pattern

Extremely short intervals (10 minutes or less) may lead to interpretive and categorization errors for normal foetuses, even though there isn't a set minimum length of testing that has been agreed upon [27].

FEATURE	BASE LINE	VARIABILITY	DECELERATION	ACCELERATION
Reassuring	110-160	>=5	None	Present
Non-reassuring	100-109 161-180	<5 for 40 -90 mins	Typical variable deceleration with over 50 % of contractions occurring for over 90 mins Single prolonged deceleration for upto 3 mins	The absence of accelerations with otherwise normal trace is of uncertain significance
Abnormal	<100	<5 for > 90 mins	Either atypical variable decelerations with over 50 % of contractions or late decelerations,both for over 30 mins Single prolonged deceleration for more than 3 mins.	The absence of accelerations with otherwise normal trace is of uncertain significance

Table 2 – Table showing characteristics of various NST pattern

CATEGORIES OF NST

CATEGORY 1	CATEGORY 2	CATEGORY 3
All of the following • **Baseline 110- 160** • **Variability- moderate** • **Late or variable deceleration – Absent** • **Early deceleration – present or absent** • **Acceleration – present or absent**	• Moderate variability with recurrent late or variable deceleration • Minimal variability with recurrent variable deceleration • Absent variability **WITHOUT** Recurrent decelerations • Bradycardia with moderate variability • Prolonged deceleration	Either: • Absent variability with: • Recurrent late deceleration **OR** • Recurrent variable deceleration • **OR** • Bradycardia • **OR** • Sinusoidal pattern

Table 3 – categories of NST

Advantages of NST:

The non-stress test undoubtedly offers benefits of its own, while being associated with a high rate of false positives and fallacies.

1) Knowing the foetus's oxygen level is helpful.

2) It is useful to evaluate the foetal reactivity to contractions and movement.

3) Variability is one of the special features of NST and cannot be detected by a fetoscope.

4) Mainly aids in deciding induction and prolonging high-risk pregnancies till fetal maturity.

DOPPLER ULTRASONOGRAPHY

The Doppler phenomenon was first described by Christian Johann Doppler in 1842, and Doppler ultrasound for foetal monitoring was first used in the 1970s [42-43]. (Fitzgerald & Drumm, 1977; McCallum, 1977).One of the most significant developments in modern obstetrics is the Doppler ultrasonography examination of uteroplacental and fetoplacental circulation [44]

Umbilical artery ultrasound can be used to determine the root cause (60%) of intrauterine growth restriction in typically developed foetuses using Doppler velocity [45]

Doppler is used to assess the following in Obstetrics:

1. Utero placental circulation – by studying the uterine artery

2. Feto placental circulation – by studying the umbilical artery

3. Fetal circulation – by studying the fetal Middle Cerebral Artery & ductus venosus.

IMPORTANT RISK FACTORS FOR WHICH DOPPLER IS ADVISED DOPPLER [46]:

- Oligohydramnios
- Suspected fetal growth retardation
- Maternal hypertension
- Previous complicated pregnancy i.e fetal retardation or death
- Maternal collagen vascular disorder (SLE, APLA)
- Maternal vascular disorder like diabetes

- Maternal blood group isoimmunization

OLIGOHYDRAMNIOS

Amniotic fluid, which represents chronic uteroplacental insufficiency, is unaffected by acute hypoxia. Oligohydramnios is a sign of increased renal artery resistance [47] in the second half of pregnancy when foetal urine makes up practically all of the amniotic fluid.Oligohydramnios can cause meconium aspiration, occasional foetal hypoxia, and cord compression [48].

Since amniotic fluid can rapidly decrease in 24 to 48 hours, Clement et al [49]. state that high-risk pregnancies require frequent ultrasound examinations of the amniotic fluid.

PREECLAMPSIA

A poor quality and quantity of maternal vascular response to placentation is linked to pre-eclampsia [50].In cases of pregnancy-induced hypertension and precclampsia, according to Fleischer and Schulman et al [51], there is insufficient trophoblastic invasion of spiral arteries and decreased blood flow in the placental vascular bed and in the umbilical artery [52], which results in increased resistance in the vessels and raises U.A PI. Uteroplacental insufficiency is the term used to characterise the condition.

DIABETES MELLITUS

Analysis of blood samples taken by cordocentesis in a research by Bradley et al [53] diabetic pregnancies showed considerable acidemia and hyperlacticemia in the absence of hypoxemia, which is probably caused by an elevated metabolic rate. In diabetic pregnancies, foetal acidemia may be the cause of unexplained stillbirths. In diabetic pregnancies, Salvesen et al. performed cordocentesis and found a substantial correlation between foetal insulin levels and the severity of foetal acidemia[54]. In 43 diabetic pregnancies, umbilical artery Doppler was

evaluated by Bracero et al [55]. They discovered a strong correlation between the resistance to flow and the level of maternal serum glucose. They also noted that high impedance was linked to a higher rate of stillbirths and neonatal morbidity. Maternal hyperglycemia, which impairs placental blood flow and was the reason.

RED BLOOD CELL ISOIMMUNISATION

According to Nicolaides et al. [56], maternal hemolytic antibodies reach the placenta and adhere to the antigens on RBCs, causing lysis in cases of ABO or RH iso immunisation. In this instance, blood constituent changes like hypoprotienemia or RBC morphology are to account for the flow impedance rather than anaemic hypoxia.

Preeclampsia and IUGR risk are elevated in cases aggravated by antiphospholipid syndrome (APLA) and systemic lupus erythematosus (SLE).

According to Nicolaides et al., APLA is characterised by placental infarction, preeclampsia, and early pregnancy loss due to thrombosis of the uteroplacental vasculature. [57]

PHYSCICS OF DOPPLER VELOCIMETRY

The Doppler principle is based on the fact that wave energy undergoes changes in frequency when it is reflected by a moving object, with the frequency shift being proportional to the reflector's velocity.Whether colour flow or spectral Doppler, ultrasound images of flow are primarily produced by observations of movement.

To detect blood movement, ultrasound scanners transmit a sequence of pulses.

From pulse to pulse, stationary tissue's echoes are same.The time it takes for the signal to return to the receiver differs just slightly in echoes from moving scatterers.

These variations can be quantified as a direct time difference or, more frequently, as a phase shift, from which the "Doppler frequency" is derived. They are then processed to produce either a color flow display or a Doppler sonogramUltrasound images are formed by reflected echoes. These waves have an amplitude (as those in A-, B- and M mode) and a frequency, which is equal to the frequency of the emitted wave, if the tissue is static. Tissue movement (e.g., blood) promotes a frequency shift (Doppler shift) in the reflected echoes.

Spectral analysis of Doppler signal contains both frequency and amplitude information of a small tissue sample. The brightness of the pixels represents the amplitude of the signal (related to Power Doppler), the vertical axis shows frequency shift (related to Color Doppler), and the horizontal axis represents time.

Doppler frequency is obtained by measuring the time difference for the signal to be returned when reflected from moving scatters [58].

DOPPLER FREQUENCY INCREASES IF [59]

1. Flow velocity increase

2. Beam is more aligned to the direction of flow

3. High transducer frequency is used.

Doppler effect / Doppler shift: The frequency of the reflected echoes changes when the reflector or the target moves. The velocity of the moving objects is directly proportional to the

change in frequency (Doppler shift frequency) [61]. When the target travels exactly in front of or behind the source or transducer, doppler shift occurs.

Doppler Equation: Thus, the Doppler frequency shift, Δf_d, is the difference between the received and transmitted frequencies, and it can be calculated by using the following formula [62]:

$$\Delta f_d = f_t - f_r = \frac{2 f_t v \cos\theta}{c}$$ where c is the speed of sound, cos is cosine, v is the flow velocity, θ is the angle between the direction of blood flow and the axis of the ultrasound beam, f_t is the transmitted frequency, and f_r is the received frequency. Therefore, the change in Doppler frequency shift is proportional to the flow velocity.

The ultrasonic beam is directed to the target at an angle known as the Doppler angle in order to obtain the Doppler signals. typically ranges from 0 to 60 degrees.

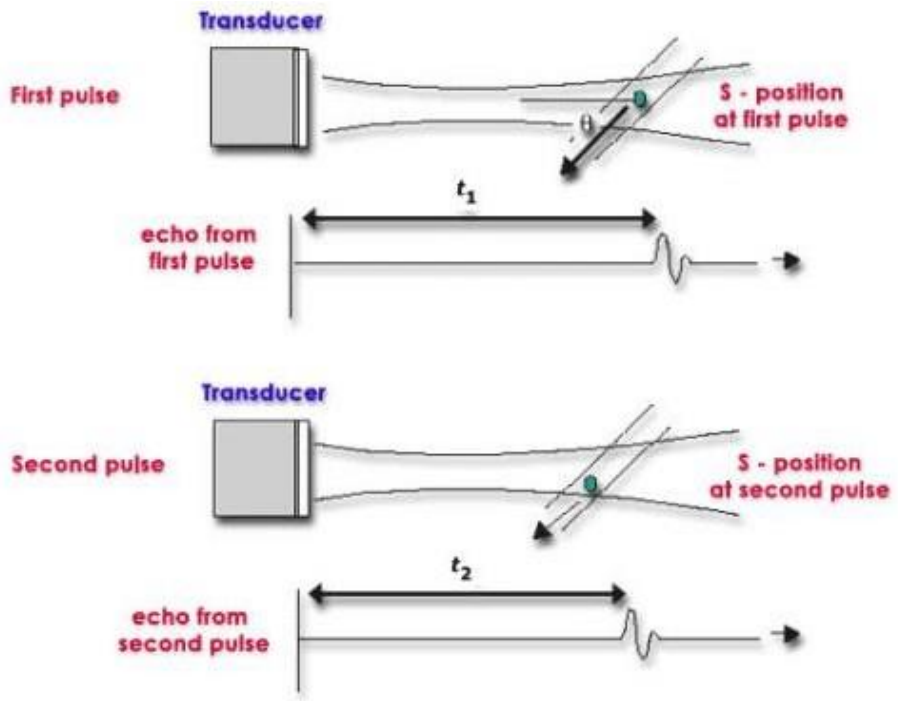


FIGURE 15- Image showing velocity measurement

The diagram depicts an ultrasound scatterer S moving at velocity V and a beam/flow angle LJ. As the scatterer passes across the beam, the velocity may be determined using the difference in transmit-to-receive time between the first and second pulses (t2).

The size of the Doppler signal is dependent on:

(1) Blood velocity: Doppler frequency increases with blood velocity [(63)].

(2) Blood velocity: Doppler frequency increases with blood velocity; Lower ultrasonic frequencies have higher penetration, much like in B-mode.

(3) The frequency selection is a compromise between increased flow sensitivity and increased penetration.

(4) The angle of insolation: As the Doppler ultrasound beam is more aligned to the flow direction (i.e., the angle LJ between the beam and the flow direction is less), the Doppler frequency increases.

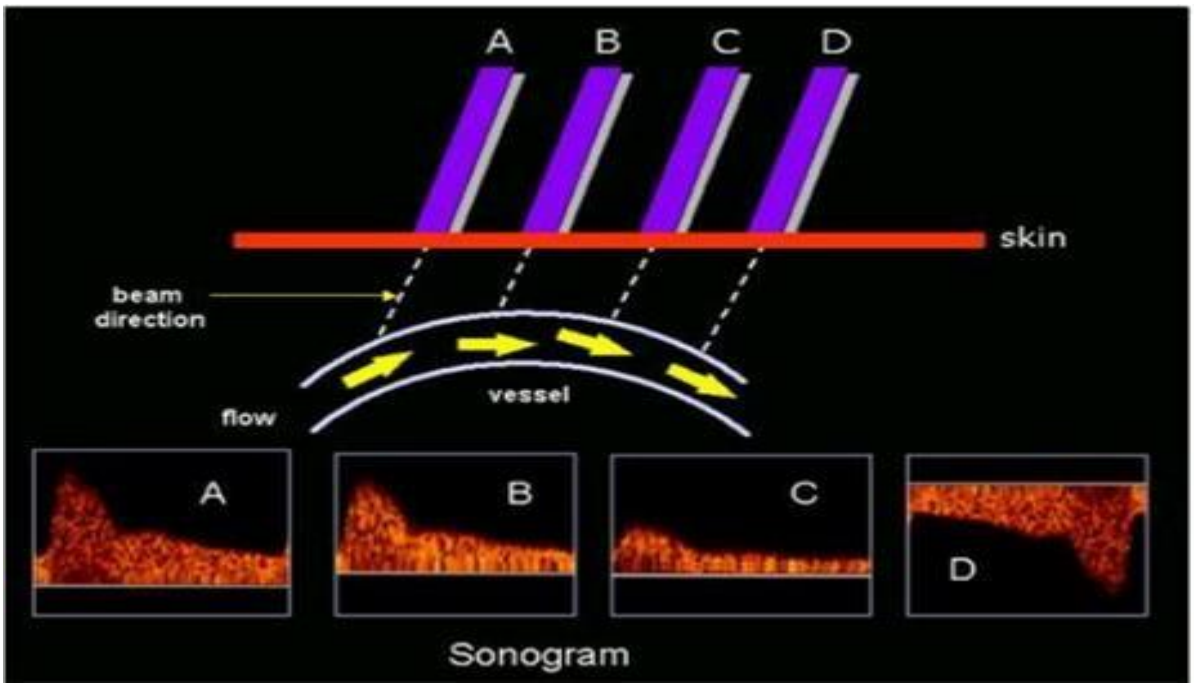


Figure 16– Effect of the Doppler angle in Sonogram

If the beam is aligned more with the direction of flow, (A) greater frequency Doppler is obtained. Doppler signals with a greater frequency are produced by beam (A) in the diagram, which is better aligned than beam (B). Nearly 90 degrees is the beam/flow angle at (C), and the Doppler signals are quite weak. A negative signal is present and the flow is moving away from the beam at (D).

Types of Doppler Setting

1. Continuous wave Doppler (CTG)
2. Pulsed wave Doppler
3. Color Doppler

- Power Doppler
- High Definition (HD) Doppler

3.Spectral (pulsed) Doppler

- Dual gate Doppler
- Tissue Doppler

Continuous wave doppler -Continuous wave Doppler (CWD) uses two distinct piezoelectric crystals to send and receive sound waves at the same time, recording each velocity along a route that is predetermined by the operator. Although it can record flow direction and velocity even at high speeds, it cannot localise the source of individual velocity elements .

Pulsed wave Doppler-In pulsed wave doppler (PWD), the user selects a small region (the sample "volume" or "gate") inside the B-mode image, and only the Doppler changes from that

region are recorded (depending on pulse repetition frequency, or the time necessary for returning sound waves). The intermittent sampling of PWD, especially at targets farther from the transducer, makes the modality susceptible to aliasing at higher velocities while avoiding the range ambiguity of continuous wave Doppler.

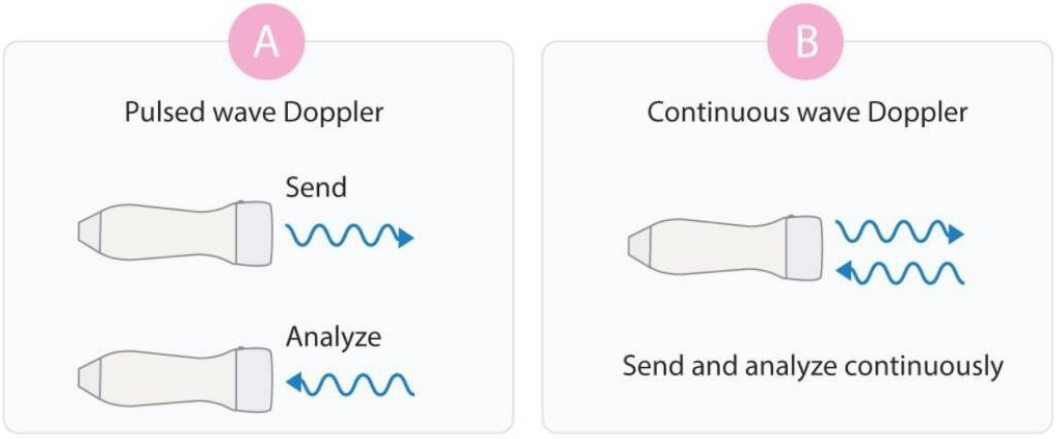


FIGURE 17- Image showing difference in pulsed wave and continuous wave doppler

Colour doppler: Color can be used to depict the speeds captured by the pulsed wave doppler in a sample volume.Brighter the colour, higher the velocity, with blue denoting velocities (movement) away from the transducer and red denoting speeds (movement) toward the transducer.

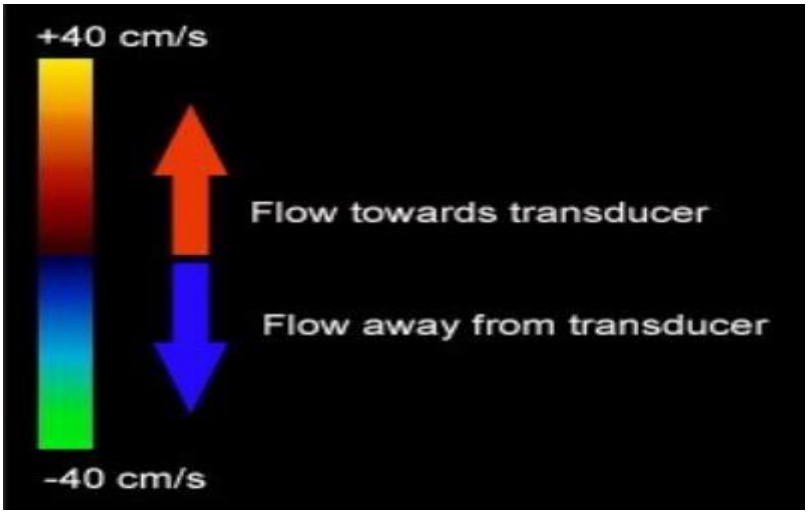


FIGURE 18 – Imaging showing colour Doppler

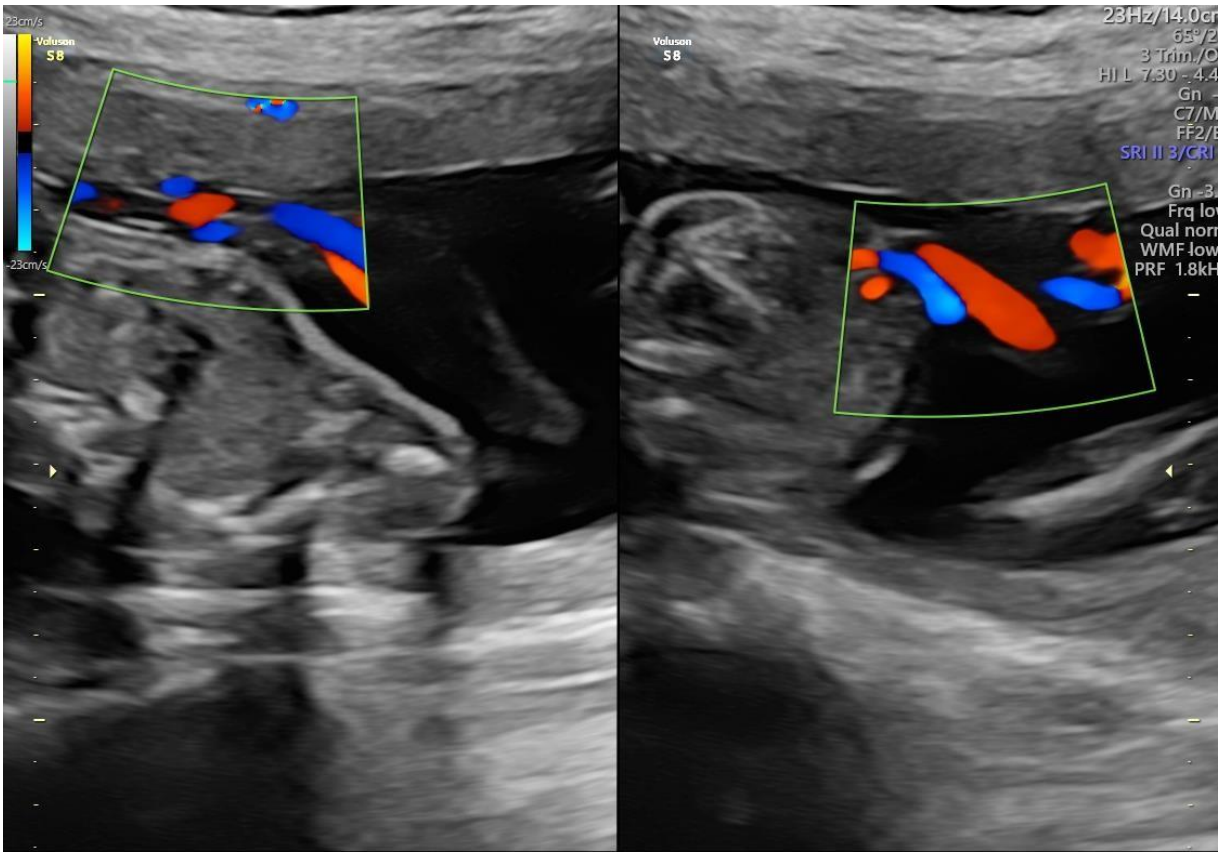


Figure 19-Color Doppler image showing umbilical artery and vein.

Power Doppler

A method called power Doppler uses the Doppler signal's amplitude to identify moving objects. There is no chance of signal aliasing with power doppler because it is independent of flow direction and velocity.

• Allows for the identification of smaller velocities than colour Doppler and is independent of angle, making it easier to perform tests in some technically difficult clinical settings.

• Has greater sensitivity than colour Doppler, albeit at the cost of flash artefacts.

FACTORS AFFECTING FLOW VELOCITY WAVEFORM

1. Maternal position: The mother should be in a semi-recumbent position with a slightly lateral tilt during Doppler examinations. This reduces the possibility of developing caval compression-induced supine hypotension syndrome [(64)].

2. Fetal Heart Rate: The arterial Doppler waveform is shaped differently depending on the foetal heart rate because of the inverse relationship between foetal heart rate and cardiac cycle duration. The diastolic phase of the cardiac cycle is lengthened and the end-diastolic frequency shift decreases when the heart rate slows. Although the foetal heart rate has an impact on the Doppler indices, there is no clinically noticeable difference when the rate is within the normal range.

3.Fetal breathing movements- Doppler tests should only be carried out in cases of foetal apnea, absence of foetal hiccup, and extreme stillness because foetal breathing movements affect the waveforms of the flow velocity from foetal arteries.

4.Blood viscosity: Research on animals has shown that higher blood viscosity is correlated with lower cardiac output and higher peripheral resistance, and vice versa.

ARTERIAL DOPPLER INDICES CALCULATION

S/D ratio gives a simple evaluation of blood flow during diastole and provides estimation of downstream resistance.

S – Peak systolic velocity

D – End diastolic velocity

S/D– Systolic /Diastolic ratio

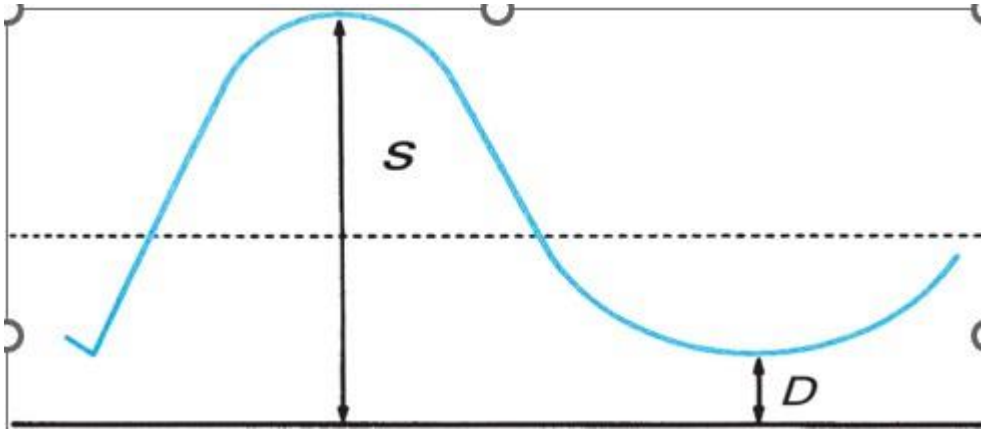


Figure 20 – S/D ratio during blood flow during diastole

Pulsiality index (S-D)/M. This depends upon the pulsatile flow of blood throughout the cardiac cycle.

The puslsiality index takes into account the mean velocity as diameter (i.e., the entire flow is taken into account, not just the diastolic flow), so it can be used to analyse data from different vessels without running into the excessive variation that can be brought on by small numbers in duration as with other indices.

Resistance Index -(S-D)/S. This depends upon the distal vascular resistance

When the diastolic flow is absent or reversed and S/D cannot be determined, the Pourcelot index, or RI, is helpful. It facilitates comparison of any waveform, regardless of diastolic flow.

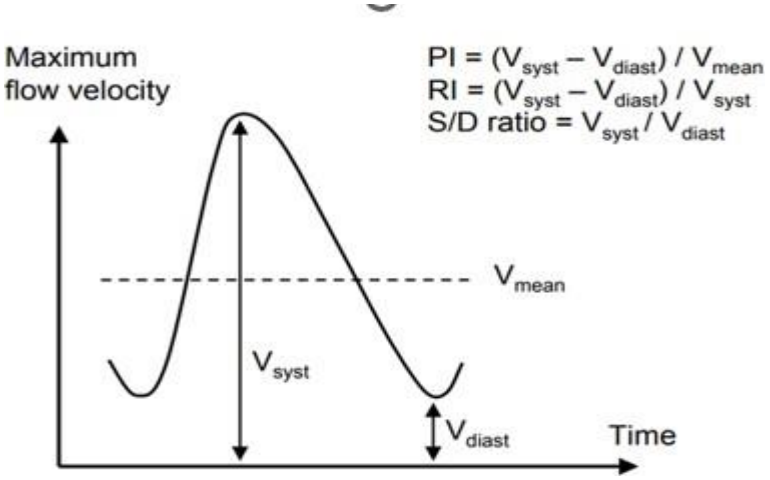


Figure 21-GRAPHICAL REPRESENTATION OF DOPPLER INDICES

Uterine artery	**RI** **PI**	**0.45-0.58** **<1.45**
Umbilical artery	**RI** **PI**	**0.6** **2ND TRIMESTER- 2.0-1.5** **3RD TRIMESTER 1.5-1.0**
Festal MCA	**RI** **PI**	**0.75-0.85** **BEFORE TERM >1.45** **AT TERM-1.0**

TABLE 4- Normal values of Doppler indices

NORMAL VALUES OF DOPPLER INDICES

The maximum Doppler shift waveform is the foundation for all of these metrics. Because the mean height of the waveform must be determined, the PI takes a little longer to calculate than the RI or S/D ratio. In obstetric Doppler, PI is a better index than RI since RI will always be 1 when diastolic velocity is 0, however PI might be any value greater than 1. As a result, PI is more informative in these circumstances.

The fact that the PI value considers the complete waveform rather than just the maximum and minimum frequencies, as in RI, is another benefit.

DOPPLER STUDY OF FETAL VESSELS

Doppler imaging is useful for pregnancy monitoring because it offers indirect proof of foetal impairment brought on by hemodynamic abnormalities [65]

UMBILICAL ARTERY DOPPLER

Doppler indices for the umbilical artery (UA), such as the pulsatility index (PI), resistance index (RI), and systolic/diastolic ratio (S/D) derived from blood flow velocities, are an essential clinical tool for assessing foetal wellness in high-risk pregnancies and predicting the outcome of foetuses with growth restriction.

The foetal abdominal wall and proximal to the placenta are the two extremities where the umbilical artery waveform is not altered. The waveform may mimic the aortic waveform, which has a generally slower diastolic velocity and a more marked systolic component, at the foetal abdominal wall.

In a healthy pregnancy, the three indices S/D, PI, and RI reduce as the pregnancy progresses.

- S/D ratio mean value decreases with fetal age

- at 20 weeks, the 50th percentile for the S/D ratio is 4
- at 30 weeks, the 50th percentile is 2.83
- at 40 weeks, the 50th percentile is 2.18

- RI mean value decreases from 0.756 to 0.609
- PI mean value decreases from 1.270 to 0.967

UTEROPLACENTAL IMPORTANCE

Doppler ultrasonography evaluation of the uteroplacental blood vessels utilising waveform indices or notching may be helpful in identifying the "at-risk" women in the early and second trimesters of pregnancy and in establishing strategies to lower maternal and foetal morbidity and/or mortality.

The umbilical artery circulation typically has a low impedance and increases end-diastolic flow with advancing gestation [(66)]. The tertiary stem villi that develop with placental maturation are directly responsible for the rise in end diastolic flow that is observed with increasing gestation as shown in the umbilical artery Doppler waveforms, which indicate the condition of the placental circulation. The absence of end-diastolic flow in the umbilical arterial Doppler waveforms, which is indicative of IUGR or probable pre-eclampsia, is caused by the obliteration of small muscular arteries in placental tertiary stem villi [(67)]

Blood flow resistance and the tertiary villous architecture are both correlated with umbilical artery waveforms.

When the resistance indices are high and the umbilical artery end diastolic velocities are low, at least 30% of the foetal villous vasculature is aberrant [(69)]

Umbilical artery end-diastolic velocities are absent or reversed, which shows that 60% to 70% of the foetal villous vasculature is compromised [69].

Umbilical cord structure: Waveforms of the umbilical artery are correlated with the tertiary villous architecture and blood flow resistance.

At least 30% of the foetal villous vasculature is aberrant when the resistance indices are high and the umbilical artery end diastolic velocities are low.

The absence or reversal of umbilical artery end-diastolic velocities indicates that 60% to 70% of the foetal villous vasculature is disrupted.

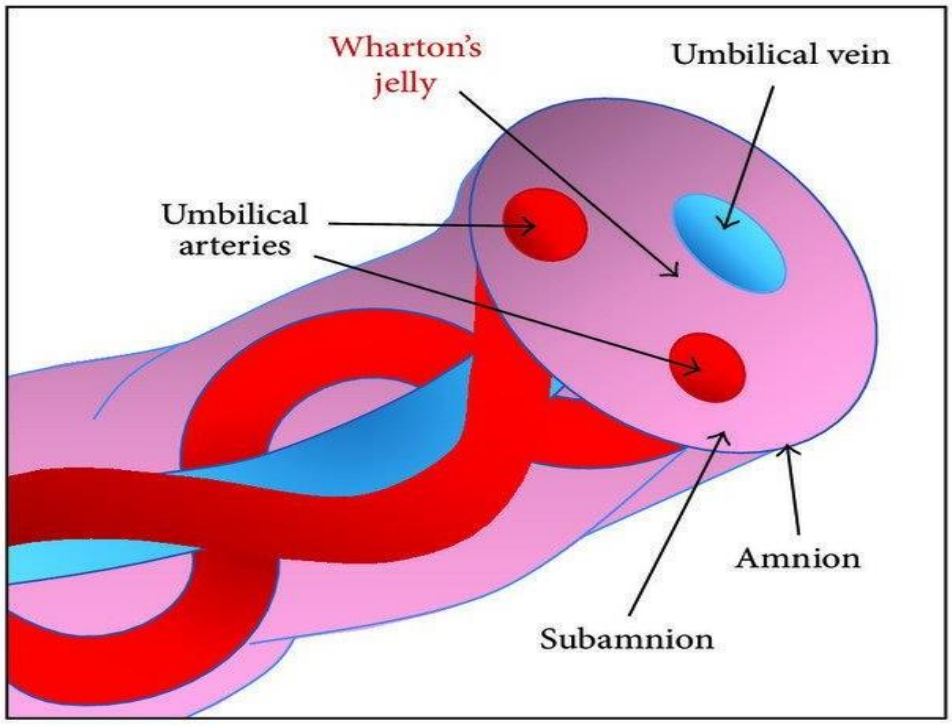


FIGURE 22 – Image showing anatomy of umbilical cord

ANATOMY: At 20 weeks of gestation, the umbilical cord vein is 4.1 mm in diameter; at 38 weeks, it is 8.3 mm in diameter [70]. The umbilical vein's cross-sectional area increases from

28 mm at 24 weeks to a maximum of about 58 mm between 34 and 38 weeks, then gradually decreases starting at 39 weeks [71]. The umbilical vein's area is about 30% bigger than the combined areas of the arteries, and as a result, its velocity, which ranges from 10 to 22 cm/s, is almost half that of either artery [72].

At 16 weeks of gestation, the umbilical arteries' diameter is 1.2+0.4mm; at term, it is 4.2+0.4mm. A decrease in Wharton's jelly's water content is thought to be the cause of the cord's diameter decline as term approaches [73].

Between the placental and foetal ends, the umbilical cord vein's diameter drops by around 1 mm, which is another variation.

The umbilical cord's arteries and veins differ from those in the rest of the foetus because the vein carries oxygenated blood to the heart while the arteries send oxygen-depleted blood back to the placenta.

Around the umbilical vein, the two umbilical arteries frequently form a cylindrical helix. One coil is present for every five centimetres of the typical umbilical cord length.The umbilical cord can develop up to 40 spirals [75] including straight portions or regions where the spiral's direction is reversed. The vein often twists around the umbilical arteries, but in 4.2% of cases, the vein may do the same with straight or hypocoiled arteries.About 90% of the time, the umbilical cord's helices, or so-called "spirals," are dextral, and the other 10% are sinistral.

The helical muscle layers in the walls of the umbilical artery are thought to be responsible for spiralling. Uncoiled or hypocoiled umbilical cords have been linked to poor pregnancy outcomes in the clinical setting, including an increase in the frequency of interventional deliveries, a higher cord pH, and heart rate disturbances. (Spurway, Jacqueline et al 2012)

UMBILICAL ARTERY FLOW - First foetal vascular studied by Doppler velocimetry was the umbilical artery.It has been demonstrated that perinatal mortality and morbidity can be decreased in high-risk obstetric circumstances using umbilical artery Doppler assessment [75]

As arterial blood flows in one direction and continuous umbilical venous blood flows in the other, the flow velocity waveforms from the umbilical cord exhibit a distinctive saw-tooth shape.

Absence or reversal of diastolic flow is visible in an irregular waveform. Before week 15, the lack of diastolic flow may be a common finding. [76]

METHOD

It is simple to examine the umbilical artery with continuous wave Doppler. In order to obtain the distinctive waveforms from the umbilical artery and vein, the transducer typically a pencil-shaped probe is placed on the mother's abdomen covering the foetus.A free-floating part of the cord is first identified using an ultrasound scan with a pulsed wave Doppler equipment, and the Doppler sample volume is then placed over an artery and a vein.

SIGNIFICANCE

The UA Doppler calculates a pulsatility index by measuring the flow resistance in the fetoplacental circulation (PI). UA flows forward in a healthy foetus. The muscular arteries in the placental villi are disrupted by an increase in placental resistance, which reduces diastolic flow.The fetoplacental circulation flow is absent and ultimately reverses as a result of this reduction. The Doppler shows both absent and reverse end-diastolic flows**.**

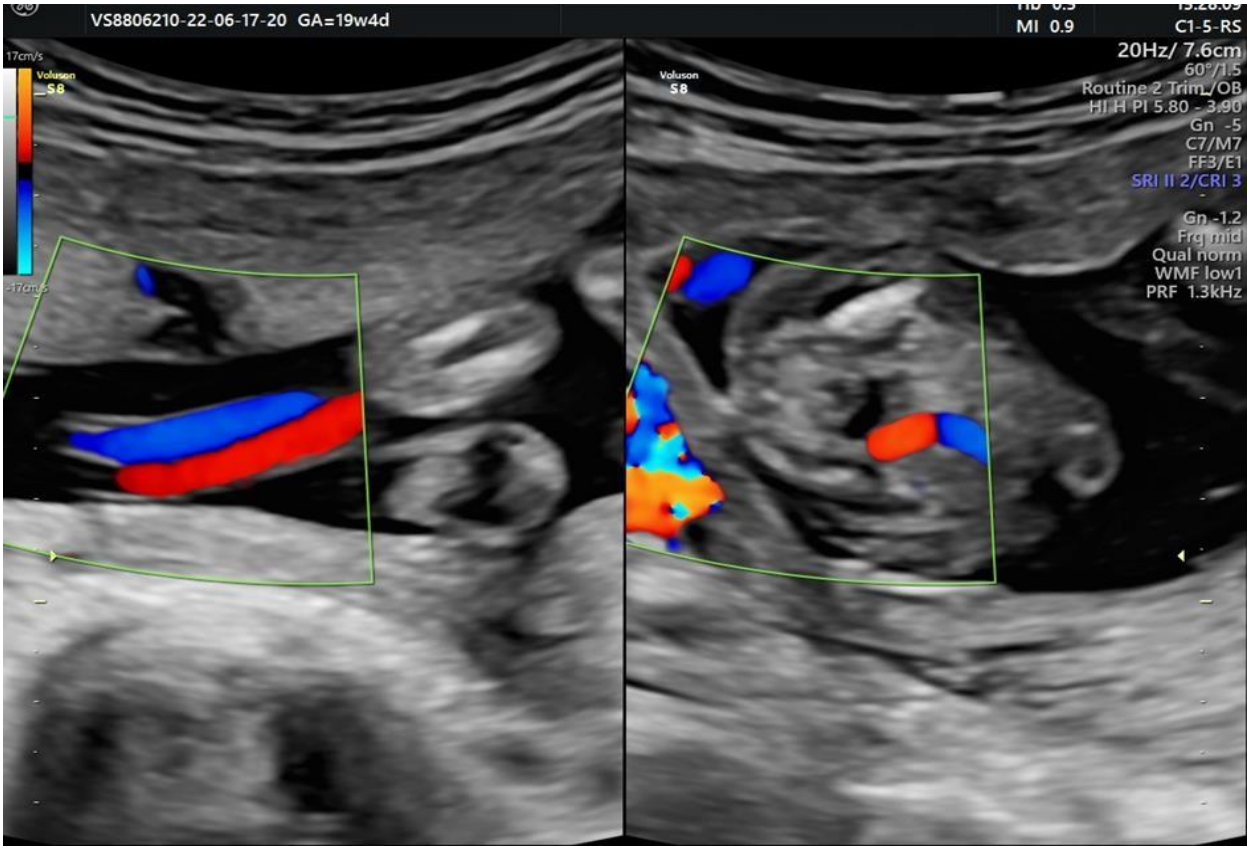


Figure 23: Color Doppler image showing umbilical artery and vein.

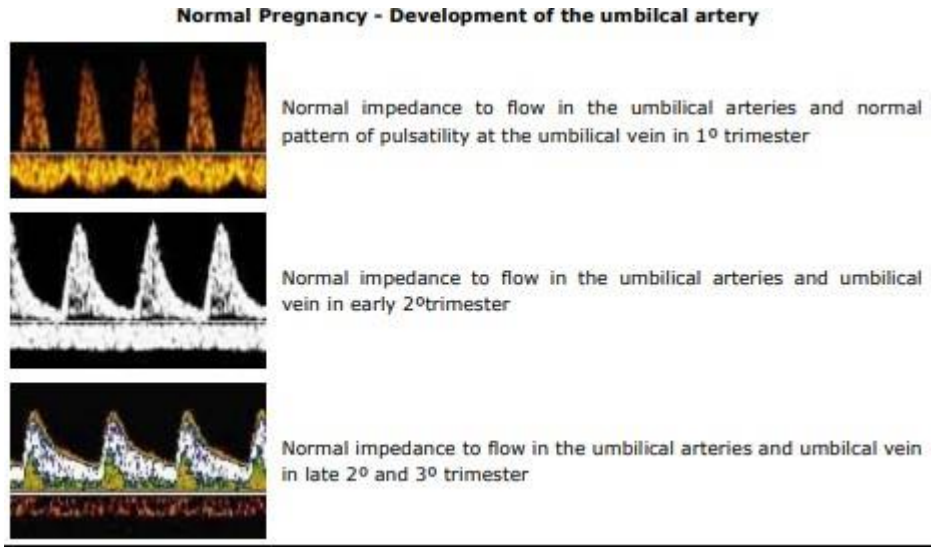


Figure 24– Image showing development of umbilical artery

ABNORMALITIES IN THE UMBILICAL ARTERY WAVEFORMS:

The end diastolic velocity increases and the impedance indices decrease as gestation progresses, based on the umbilical artery Doppler. As a result, the following are umbilical artery waveform irregularities.

1. Decrease in diastolic flow

2. There is no diastolic flow

3.Reversed end diastolic flow

IMPORTANCE

- Absent end- diastolic flow is an useful feature, underlying fetal vascular stress which indicated fetal compromise
- Reversed diastolic flow in the umbilical arterial circulation represents an advanced stage of placental compromise and is associated with more than 70% of placental arterial obliteration.
- Severe FGR and oligohydramnios are frequently linked when end-diastolic flow in the umbilical artery is absent or reversed.
- For the umbilical artery, an abnormal test result is one that shows a loss of end-diastolic velocity or a Doppler index measurement that is more than 2 SDs above the gestational age mean[(77)].
- The earliest Doppler indication of a slight decline in foetal villous perfusion may be a reduction in umbilical venous blood flow volume.
- As diagnostic tools, middle cerebral artery brain sparing and high umbilical artery blood flow resistance show a placenta sufficiency.

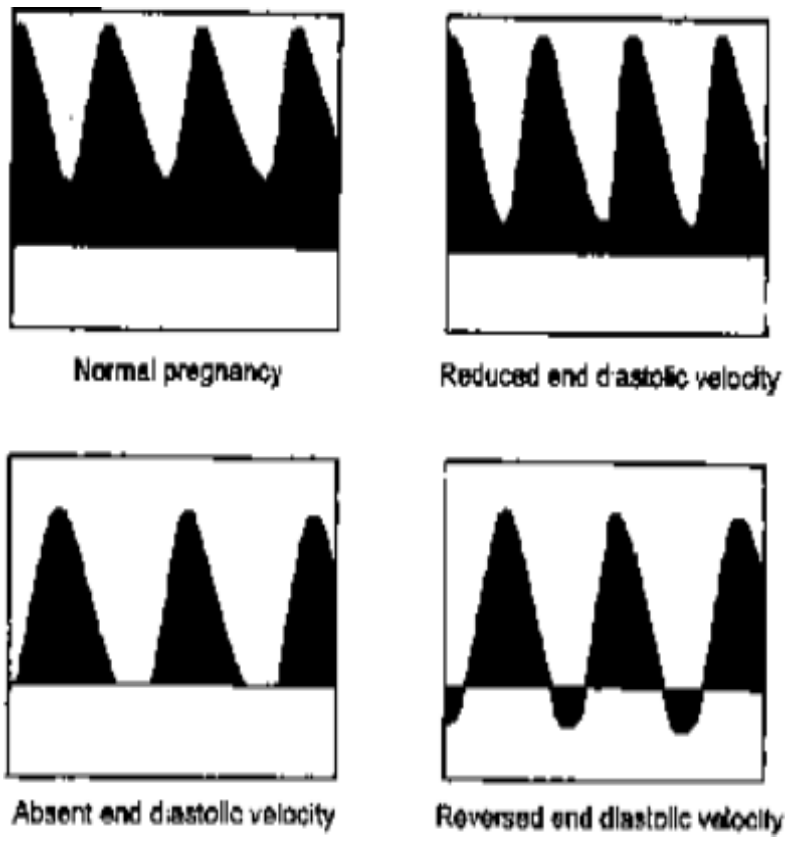


Figure 25- Image showing different abnormal umbilical artery waveforms

Factors affecting the umbilical artery Doppler waveform in a normal pregnancy:

1. In pregnancies with normal umbilical arterial blood flow, there are no noticeable diurnal fluctuations or significant daily variations.

2. It is influenced by gestational age; as pregnancy progresses, the end diastolic velocity rises and the S/D ratio gradually decreases.

3. Fetal heart rate: The S/D ratio, pulsatility index, and resistance index all rise as a result of bradycardia, which causes the diastolic phase to lengthen and the end-diastolic velocity to decrease. A tachycardia causes changes that are the opposite.

4. Fetal breathing: Doppler indices should only be taken during foetal apnea since breathing alters intrathoracic and central circulatory dynamics noticeably. These changes are linked to

variations in the peak systolic and end-diastolic components of the maximum frequency shift from one cardiac cycle to the next. [78]

5. Site of Doppler sampling in the cord: A free umbilical cord loop floating in amniotic fluid is examined with continuous or pulsed Doppler ultrasonography far from the foetal and placental insertions (e.g., midcord segment)

The highest S/D ratios are achieved when the sample is taken close to the foetal abdominal wall, while lower S/D ratios are obtained when it is taken close to the placental location**.**

FETAL MIDDLE CEREBRAL ARTERY:

In 1995, Mari et al. (44) published the outcomes of their first thorough investigation of middle cerebral artery peak systolic velocity (MCA-PSV).

More than 80% of cerebral blood flow is carried by the MCA, which is the brain conduit in the foetus that is easiest to image using ultrasound technology.

Middle Cerebral Artery was selected for this study because it has the benefit of being quite reproducible. The MCA vascular bed resistance remains constant during pregnancy, in contrast to the uterine and umbilical arteries, whose vascular bed changes constantly as gestational age increases [79]. The cerebral circulation typically has a constant forward flow throughout the cardiac cycle and a high impedance. Fetal hypoxemia causes a central redistribution of blood flow, increasing blood flow to the heart, brain, and adrenals while decreasing blood flow to the peripheral and placental circulations. The auto regulating mechanism restricts the splanchnic, renal, and pulmonary vascular beds during hypoxia, redistributing arterial blood flow to the brain and myocardium. As a result, the MCA's diastolic flow is increased, and PI and RI are decreased.

The brain-sparing effect, which is the redistribution of blood flow, is crucial for embryonic adaptation to oxygen deprivation.

This results in a decline in diastolic flow and an increase in cerebral vascular resistance, both of which signal a poor prognosis.

When there is increased cardiac output, which is reflected in the foetal MCA by an increase, Doppler analysis of the MCA is also helpful in foetal anaemia.

METHOD: At the biparietal diameter, a transverse image of the foetal brain is acquired. The transducer is then positioned so that the smaller wing of the sphenoid bone is at the base of the skull.The middle cerebral artery can be detected using colour flow imaging as a significant lateral branch of the circle of Willis that runs anterolaterally near the boundary between the anterior and middle cerebral fossae.

Because foetal head compression is associated to changes in intracranial arterial waveforms dysfunction, it is important to use the transducer with the utmost care during the experiments.

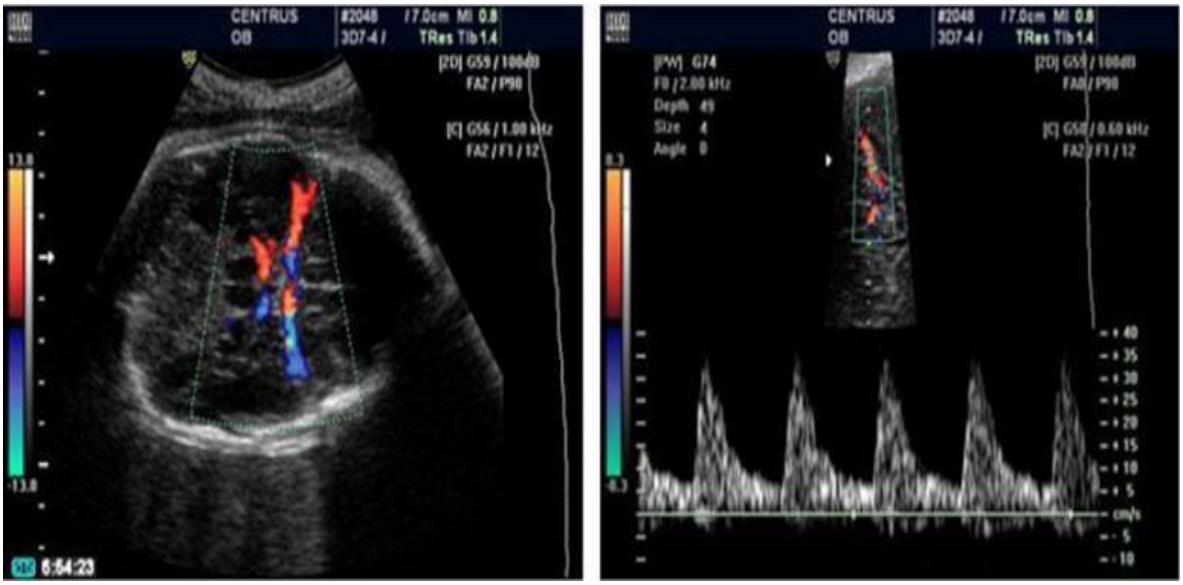


Figure 26– Transverse view of the fetal head with color Doppler showing the circle of Wills (left). Flow velocity waveforms from the middle cerebral artery at 32 weeks of gestation (right)

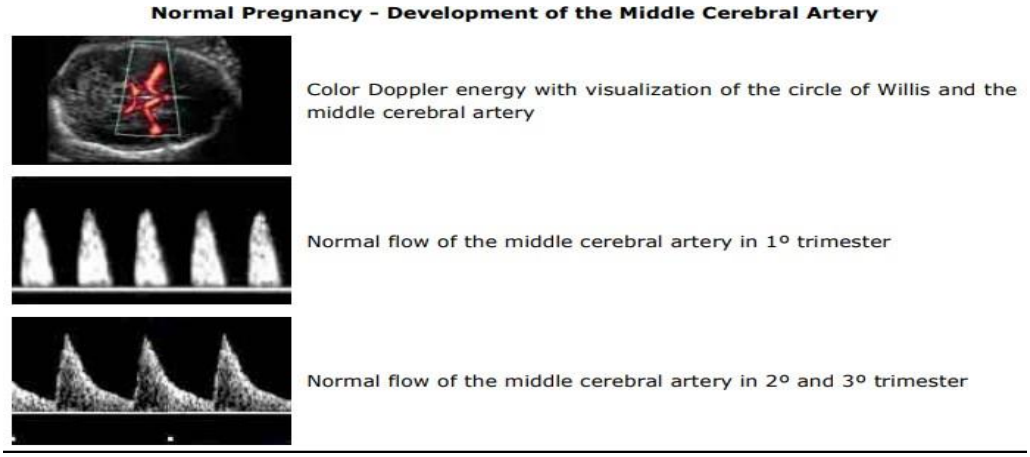


Figure 27- Development of the middle Cerebral Artery

SIGNIFICANCE OF MCA DOPPLER IN ANTEPARTUM SURVEILLANCE

1. To diagnose suspected fetal growth restriction / compromise / hypoxia
2. Screening for severe early onset FGR or pre-eclampsia in high-risk women
3. Assessing for fetal anaemia
4. MCDA twins

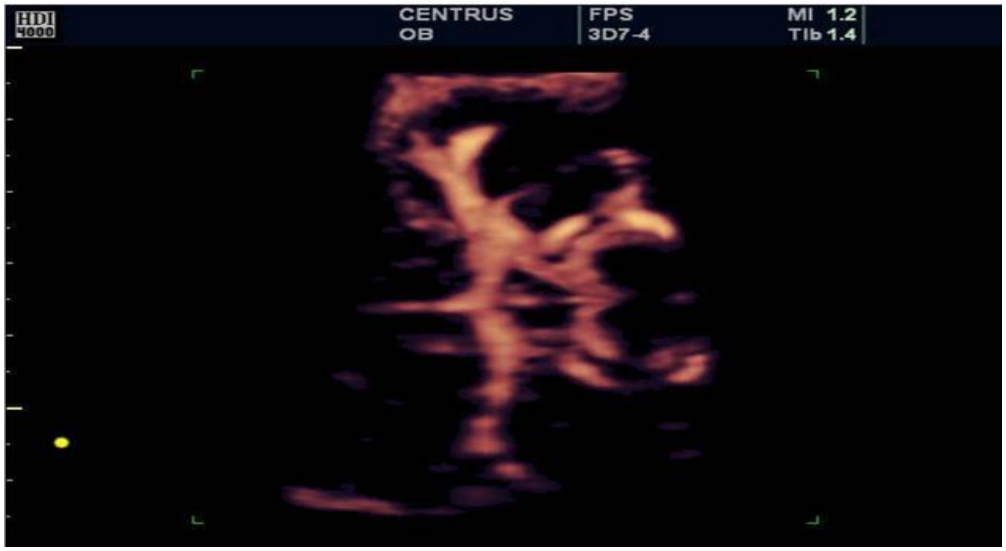
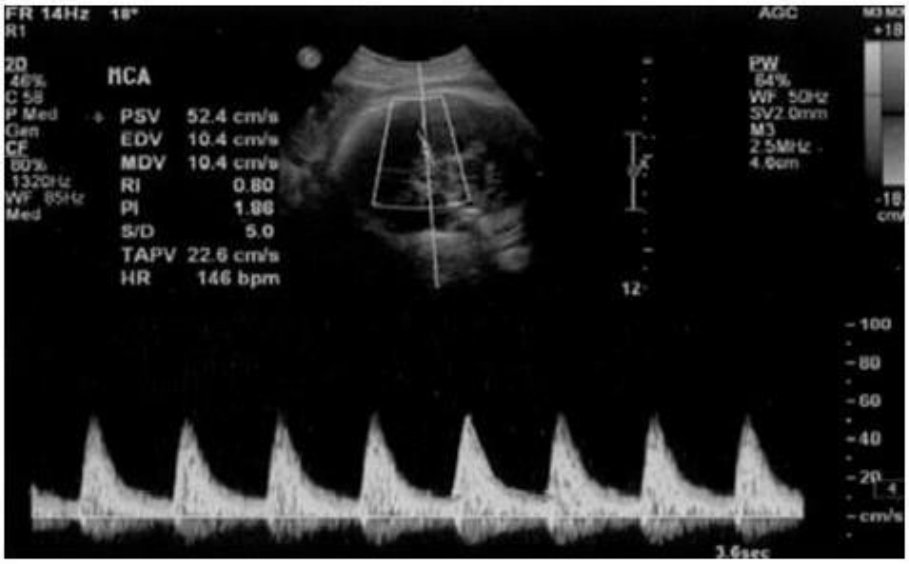


Figure 28- Transverse view of the fetal head color 3D power Doppler showing the circle of Wills and digital subtraction of the grayscale

NORMAL MCA WAVEFORM



ABNORMAL MCA WAVEFORM

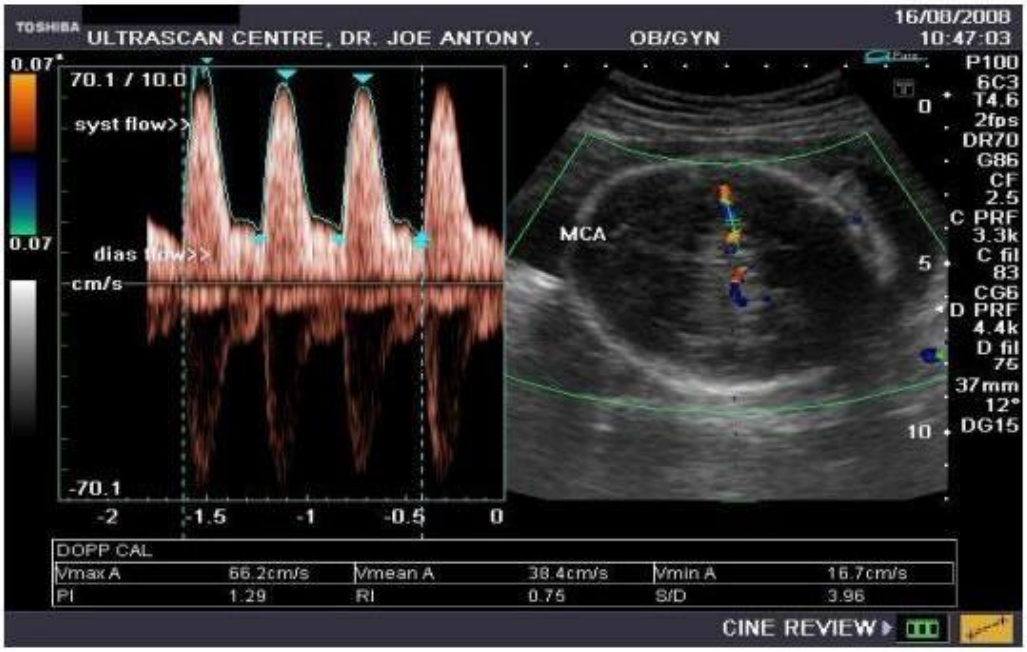


Figure 29a – Normal MCA waveform Figure 29 b – Abnormal MCA waveform

CEREBRO PLACENTAL RATIO:

It is the ratio of umbilical artery resistance to MCA resistance.

It serves as a more accurate indicator of foetal hypoxia. It is greater than 1 in healthy foetuses, while it is less than or equal to 1 in foetal hypoxia [(80)].

Pathophysiology

Afterload can have a specific impact on each ventricle due to the foetal circulation's special arrangements.

As a result, individual changes in afterload may affect the relative contributions of different ventricles to the overall cardiac output.

Reduced left ventricular afterload in this situation is expected to lead to better oxygen delivery to the brain.

Clinical significance: In both severe and mild cases of IUGR, the cerebroplacental ratio is an earlier and more sensitive predictor of unfavorable outcome than either the middle cerebral artery alone or the umbilical artery alone, and it correlates better with adverse outcomes.

Measurement

It is calculated by dividing the Doppler pulsatility index of the middle cerebral artery by the umbilical artery (UA) pulsatility index:

CPR = MCA PI / UA PI

The index will show a slight rise in placental resistance as well as a slight decrease in foetal brain vascular resistance. There are several disorders that can result in an aberrant cerebroplacental ratio:

- low normal range MCA and upper normal range UA PI
- abnormal low MCA and normal UA PI
- abnormal low MCA and high UA PI

Fetal middle cerebral arterial peak systolic velocity

The fetal middle cerebral arterial (MCA) peak systolic velocity (PSV) is an important parameter in fetal MCA Doppler assessment.

Measurement

The angle of the ultrasound beam and the direction of blood flow should be 0°, and the foetal MCA should be sampled 2 mm from the origin of the foetal internal carotid artery. Typically, the peak systolic velocity (PSV) value with the highest value is used.

Interpretation

- Reliable between 18-35 weeks
- increased PSV can indicate moderate-to-severe anemia in non-hydrops fetuses

Fetal middle cerebral artery (MCA) pulsatility index (PI) is a crucial variable utilised in the evaluation of the foetal middle cerebral arterial Doppler. It is computed by dividing the time-averaged (mean) velocity (TAV) by the end-diastolic velocity (EDV), which is subtracted from the peak systolic velocity (PSV)

PI = (PSV - EDV) / TAV

SIGNIFICANCE

Typically, the foetal MCA PI has a high value. From around week 28 forward, the mean value (normal reference range) gradually declines throughout gestation. A low PI reflects the foetal head sparing theory's shift of cardiac output to the brain**.**

INTERPRETATION

- Normally, there is minimal antegrade flow in foetal diastole because of the high resistance flow of the foetal MCA, but in pathological conditions, this can change to a low resistance flow, mostly because of the foetal head sparing theory.

• Ironically, when the disease has not yet resolved in some circumstances, such as with significant cerebral edema, the flow might return back to a high resistance pattern; this is a very bad prognostic indicator**.**

METHOD OF COLLECTION OF DATA

Patients who presented to the obstetric unit at BLDE (Deemed to Be University) Shri B. M. Patil Medical College Hospital & Research Centre, Vijayapura Karnataka, India met the below inclusion criteria were recruited in this study to determine the efficacy of MBBP vs Doppler studies to determine perinatal outcome in high- risk pregnancies

INCLUSION CRITERIA

Singleton pregnancy above 37weeks of gestation and high-risk pregnancies which includes:

- Pregnancy-induced hypertension (PIH)
- Post-dated pregnancy (>42 weeks)
- Foetal growth restriction (FGR)
- Gestational diabetes mellitus (GDM)
- Maternal heart disease
- Anemia
- Intrahepatic cholestasis of pregnancy (IHCP)
- RH negative status
- Amniotic fluid disorders
- Hypothyroidism

EXCLUSION CRITERIA

- Below 37 weeks of gestation
- Multiple gestation

- Low-risk pregnancies
- Who are not willing to participate in the studies

SAMPLE SIZE – 150 patients

Sample size calculation

With the anticipated Proportion of adverse perinatal outcomes among high-risk pregnancy 63% [81], the study required a minimum sample size of **140 patients** with A 95**%** level of confidence and 8% absolute precision**.**

Formula used

$$\mathbf{n = z^2pq/ d^2.}$$

Where Z= Z statistic at α level of significance

d^2= Absolute error

P= Proportion rate

q= 100-p

Statistical Analysis

- The data obtained was entered in a Microsoft Excel sheet, and statistical analysis was performed using a statistical package for the social sciences (SPSS Verson 20).
- Results were presented as Mean (Median) ±SD, counts and percentages, and diagrams.
- For normally distributed continuous variables between the groups were compared using ANOVA, for not normally distributed variables Kruslal walli's test were used.
- Categorical variables between the four groups were compared using Chi square test.

- $p<0.05$ were considered statistically significant. All statistical tests will be performed two tailed

METHODOLOGY

MATERIALS AND METHODS: This is a prospective observational and comparative study. All the patients who fulfilled the inclusion criteria and were willing to participate in the study were taken into the study.

Investigations:

Routine investigations (complete blood count (CBC), blood group and RH typing were also done.

Special investigations; USG- AFI and NST, Doppler studies (umbilical artery and MCA)

NONSTRESS TEST

Outcomes of nonstress tests are considered reactive or nonreactive. Reactivity has been used to convey many meanings but according to ACOG, the non-stress test is typically regarded as reactive or normal if there are two or more foetal heart rate accelerations within 20 minutes, with or without foetal movement perceptible to the mother.

Amniotic Fluid Index (AFI)

The gravid uterus is divided into four imaginary quadrants to calculate the amniotic fluid index. The uterus is divided into right and left halves using the linea nigra. The top and lower parts are split at the umbilicus.

The transducer is maintained perpendicular to the floor and parallel to the patient's longitudinal axis. Each quadrant's deepest, clearest, vertical fluid pocket is measured in centimetres. The AFI is then calculated by adding the four pocket measurements. The typical AFI ranges from

5 to 25 cm and any derangement from these values are considered abnormal.

Doppler study

The umbilical cord's indices measured at its placental, free loop, and foetal ends are all different, with the foetal end's impedance being the highest. The foetal end is probably where the changes in the indices will be noticed earliest. The measures should ideally be taken in the free cord, but for consistency in recording in cases that are being followed up, a fixed point, such as the foetal end, placental end, or intra-abdominal section, would be preferable.

The foetal head needs to be in the transverse plane for an accurate measurement. It is important to obtain and magnify an axial section of the brain that includes the thalami and the sphenoid bone wings. When using colour or power Doppler ultrasound near the base of the skull, the MCA vessels are frequently discovered covering the anterior wing of the sphenoid bone. Since the systolic velocity of this vessel diminishes with distance from its place of origin in the internal carotid artery, the reading should be taken near to that location. It is recommended to utilise an angle of insonation of about 15 degrees; normally, an angle of around 0 degrees can be attained by moving the transducer on the mother's abdomen.

Doppler studies are considered abnormal when any of the following parameters are met [59]

- UA>95th percentile pulsatility index for the gestational age.
- End-diastolic flow in the umbilical vein is absent or reversed, and after 30 weeks of pregnancy,
- The S/D ratio in the umbilical artery is greater than 3.
- RI of middle cerebral artery <5th percentile for the gestational age.
- Presence or absence of end diastolic flow or reversal of end diastolic flow in umblical artery.
- Presence of brain sparing effect in middle cerebral artery.

Based on the Doppler velocimetry and MBPP results, the participants were divided into four

groups [59]:

• A-Normal MBPP and normal Doppler velocimetry

• B-Normal MBPP and abnormal Doppler velocimetry

• C-Abnormal MBPP and normal Doppler velocimetry

• D-Abnormal MBPP and abnormal Doppler velocimetry.

The modified biophysical profile will be considered abnormal if any of the following parameters are deranged AFI or NST

Perinatal outcomes will be noted within 48 hours of delivery

The need for operative delivery due to fetal compromise will also be noted.

In our study adverse perinatal outcome were measured in terms of the following factors**.**

- NICU admission
- Neonatal Outcome
- APGAR At 5 Minutes
- Fetal Distress Intrapartum
- Caesarean section due to fetal distress
- Resuscitation Required at Birth
- Neonatal Complications
- Meconium-stained liquor

RESULTS

A total of 150 patients who met the pre-determined criteria who presented to labour room at BLDE hospital, Vijayapura were recruited in this study to determine the efficacy of MBBP vs Doppler studies to determine perinatal outcome in high- risk pregnancies.

Patients were subjected to both MBPP (NST + AFI) and Doppler studies (Umbilical artery and MCA) within 72 hours of delivery.

Following are the results of the study as per statistical analysis of all the cases, our study group was divided into the following groups

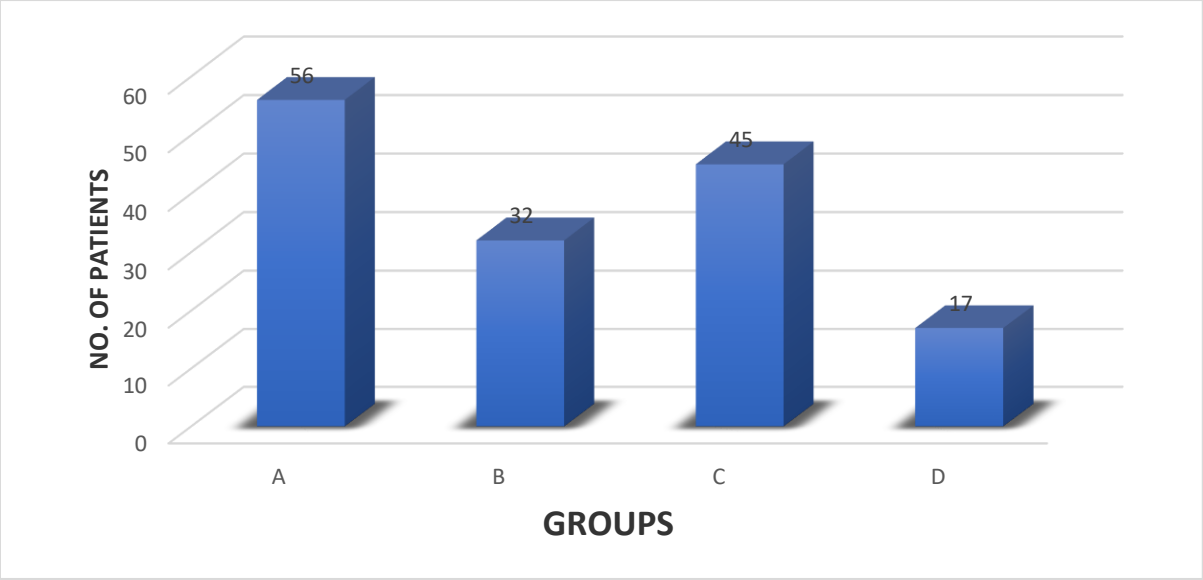
- A-Normal MBPP and normal Doppler velocimetry
- B-Normal MBPP and abnormal Doppler velocimetry
- C-Abnormal MBPP and normal Doppler velocimetry
- D-Abnormal MBPP and abnormal Doppler velocimetry

GROUP-WISE DISTRIBUTION

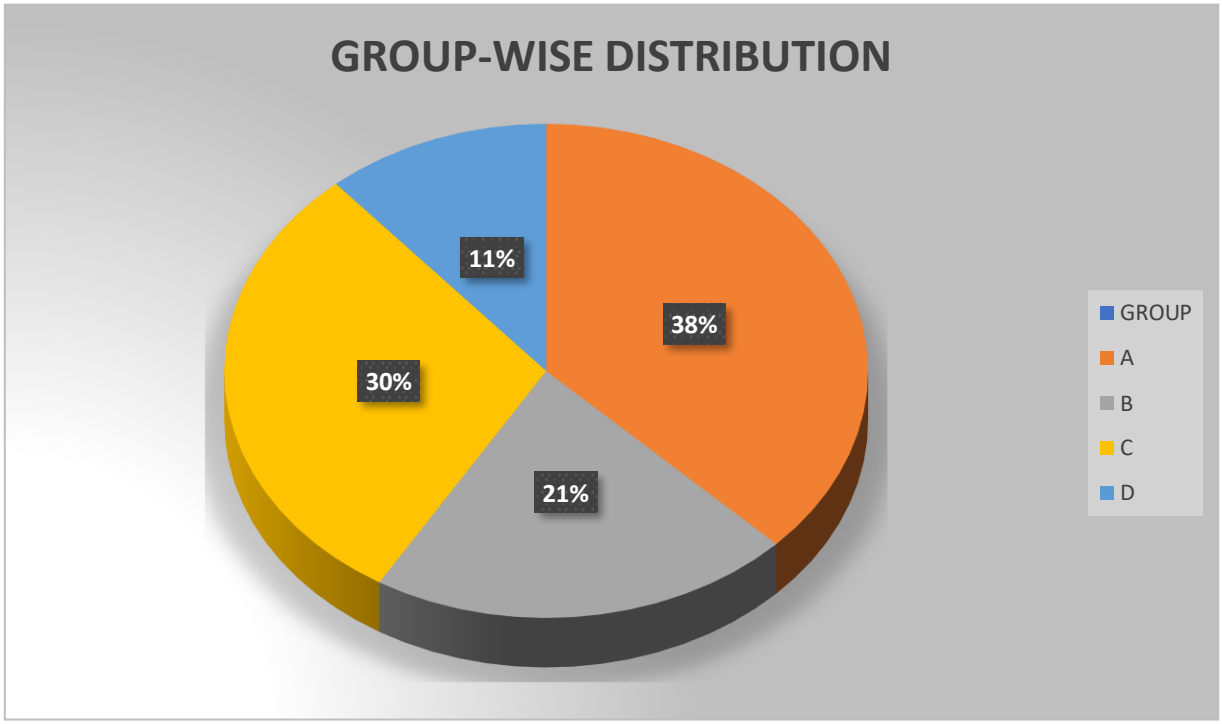
Patients were then categorised into 4 groups according to the methodology of this study.

GROUP	NUMBER OF PATIENTS	FREQUENCY
A (normal MBPP and normal Doppler studies)	56	38%
B (abnormal Doppler and normal MBPP)	32	21%
C (abnormal MBPP and normal doppler studies)	45	30%
D (Abnormal doppler and Abnormal MBPP)	17	11%

TABLE 5 – GROUP DISTRIBUTION



GRAPH 1 – BAR DIAGRAM SHOWING GROUP DISTRIBUTION



GRAPH 2 – PIE CHART SHOWING GROUP WISE DISTRIBUTION

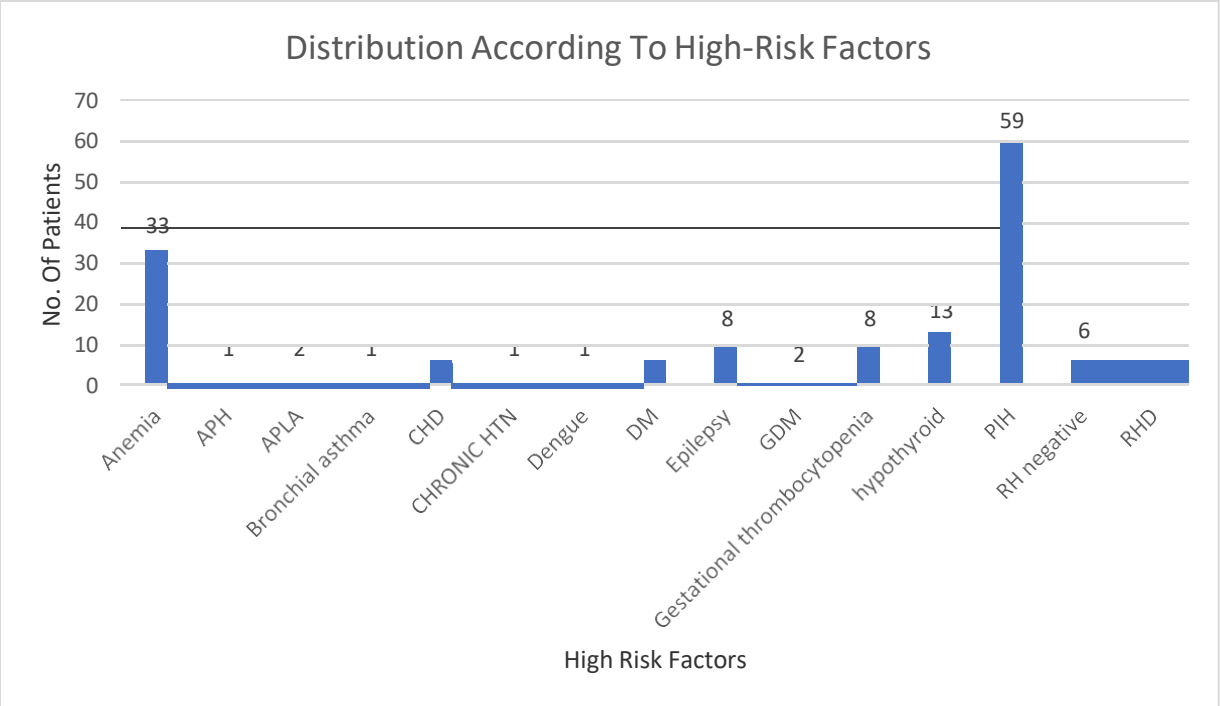
As seen in the above graph, 56 (38%) of the patients met the criteria of Group A (Normal MBPP and Normal Doppler studies), 32 (21%) in Group B (Abnormal Doppler studies and Normal MBPP),45 (30%) in Group C (Abnormal MBPP and Normal Doppler studies) and 17 (11%) in group D (Abnormal MBPP and Abnormal Doppler studies

HIGH RISK FACTOR DISTRIBUTION

Our study included only high-risk pregnancies; the following table shows the high-risk factors present in the study group.

HIGH RISK FACTOR	FREGUENCY	PERCENTAGE
Anemia	33	22.00%
APH	1	0.67%
APLA	2	1.33%
Congenital Heart Disease	6	4.00%
Chronic HTN	1	0.67%
DM	6	4.00%
Epilepsy	8	5.33%
GDM	2	1.33%
Gestational Thrombocytopenia	9	6.00%
Hypothyroid	13	8.67%
PIH	60	40.00%
RH Negative Pregnancy	6	4.00%
Rheumatic Heart Disease	3	2.00%

Table 6 – Distribution of patients with respect to risk factors.



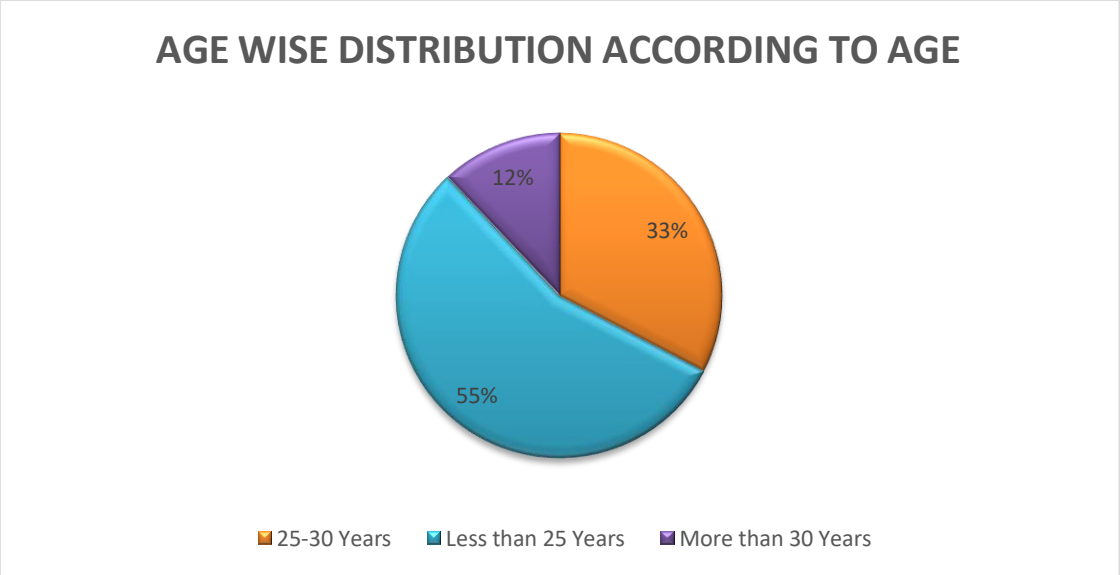
Graph 3 – Bar chart showing distribution of patients according to high risk factors

It was observed from the above data, the high-risk factor for the greatest number of patients, which accounted for 39.33% of patients, was pregnancy-induced hypertension, followed by anaemia (22%). 13 out of 150 individuals (8.7%) were found to have hypothyroidism 9 had gestational thrombocytopenia (6%).8 patients were known case of epilepsy. Each of the following (congenital heart disease, DM and RH negative pregnancy) had 6 patients each (4%).

AGE WISE DISTRIBUTION

AGE	FREQUENCY	PERCENTAGE
Less than 25 Years	83	55.33%
25-30 Years	49	32.67%
More than 30 Years	18	12.00%
Total	150	100%

Table 7 -Distribution of patients with respect to age

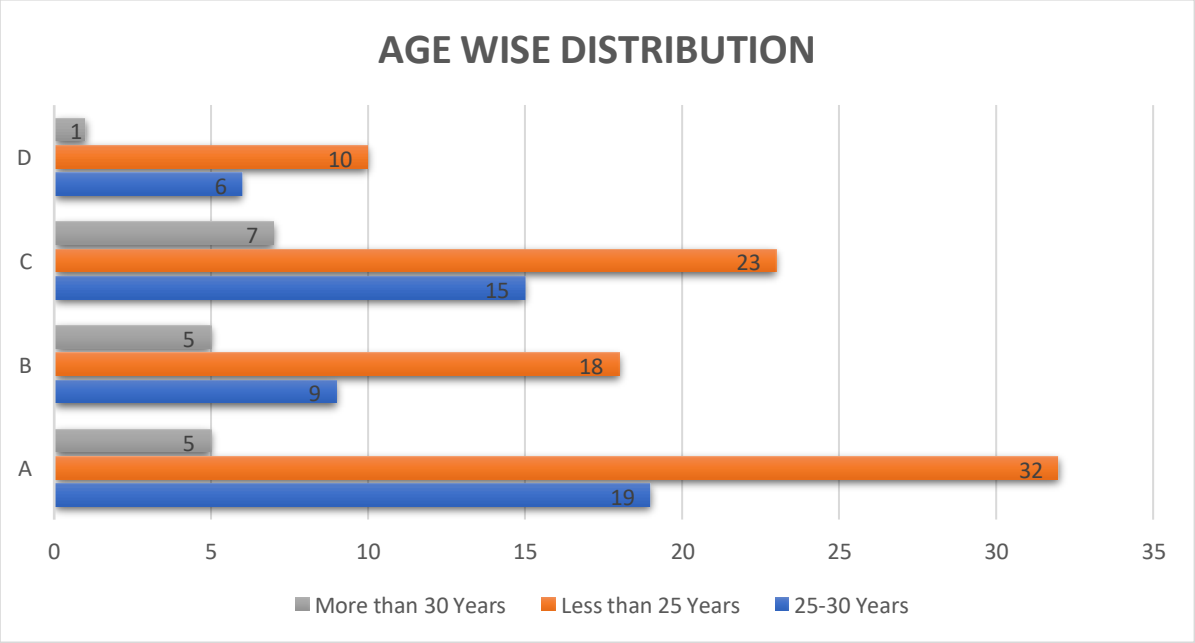


Graph 4 -PIE CHART SHOWING AGE WISE DISTRIBUTION

From the above data it was observed that maximum number of patients i.e., 83 patients were of the age below 25 years (55.33%) while least number of patients were above 30 years i.e., 18 (12%) while 49 patients were of the age group 25 to 30 years (32.67%).

		GROUP				Total	P Value
		A	B	C	D		
	Less than 25 Years	32	18	23	10	83	
AGE CATEGORY	25-30 Years	19	9	15	6	49	0.891
	More than 30 Years	5	5	7	1	18	
	P value – statistically non-significant						

Table 8 – Distribution of patients with respect to age in different groups.



Graph 5 - Bar diagram showing distribution of age according to groups

From the above tables it was noted that:

Group A (Normal Doppler Studies and Normal MBPP) – 32 among 56 patients were less than 25 years of age (57.7%).

Group B -18among 32 patients were less than 25 years of age (56.2%)

Group C B (Normal Doppler studies and Abnormal MBPP) - 23 among 45 patients were less than 25 years of age (51.1%)

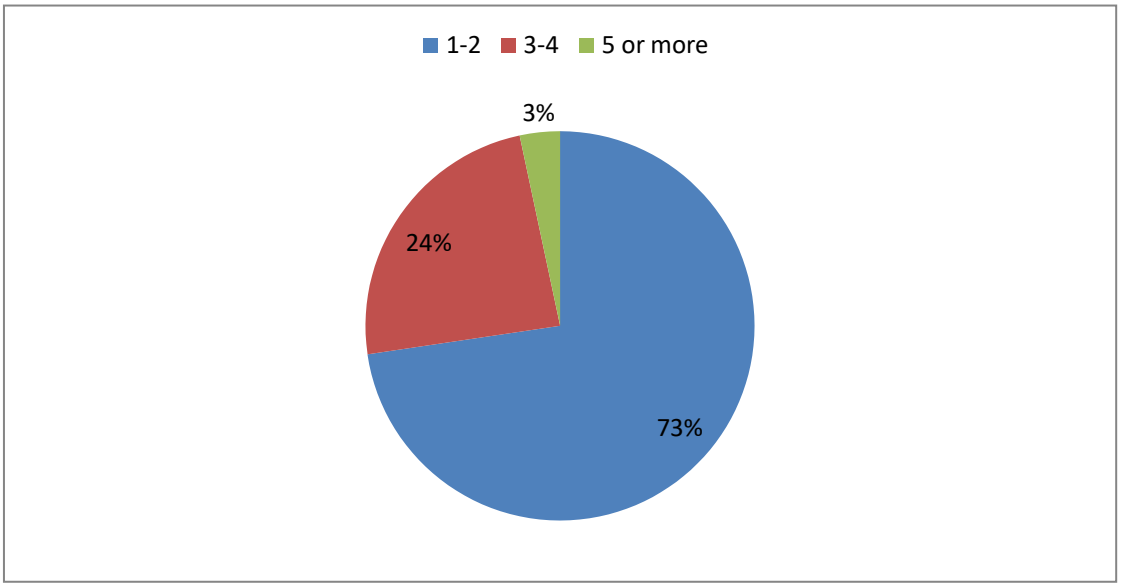
Group D B (Abnormal Doppler studies and Abnormal MBPP)– 10 among 17 patients were less than 25 years of age (58.8%)

The difference among them were noted but were not statistically significant p=0.891

OBSETERIC SCORE WISE DISTRIBUTION

		Frequency	Percent
GRAVIDA	1-2	109	72.7
	3-4	36	24.0
	5 or more	5	3.3
	Total	150	100.0

Table 9 – Obstetric score distribution

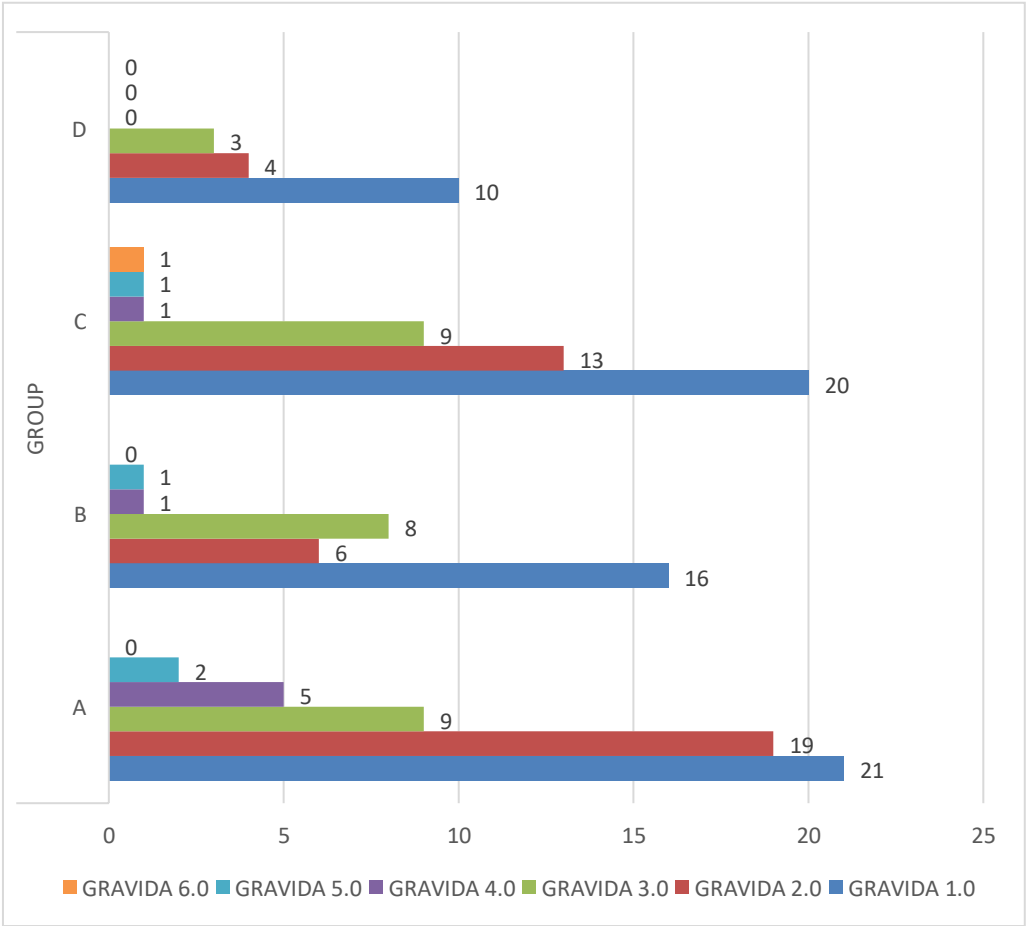


Graph 6 – Pie chart showing obstetric wise distribution

From the above graph we can infer that majority of the patients were of the parity 1-2 i.e., 109 (72.7%)

		GRAVIDA			P Value
		1-2	3-4	5 or more	
GROUP	A	40	14	2	0.95
	B	22	9	1	
	C	33	10	2	
	D	14	3	0	
Total		109	36	5	

Table 10– distribution according to obstetric score with respect to groups



Graph 7 –Bar diagram showing distribution of patient with respect obstetric score with respect to groups.

As seen from the above table 67 patients (44.7%) out of 150 patients were primigravida who had a high-risk pregnancy which was significantly lower than multigravida patients (55.3%).

According to Groups the results were as follows:

Group A -21 patients were primigravida (37.5%) while 35 were multigravida (62.5%) among 56 patients

Group B -16 patients were primigravida (50%) while 16 were multigravida (50%) among 32 patients

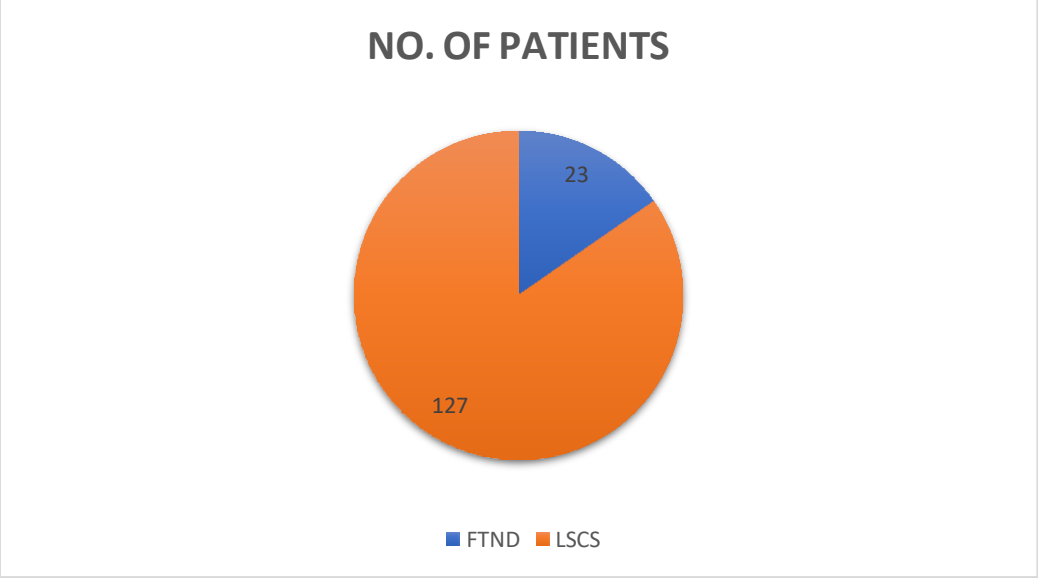
Group C -20 patients were primigravida (44.4%) while 25 were multigravida (55.6%) among 45 patients

Group D -10 patients were primigravida (58.8%) while 7 were multigravida (42.2%) among 17 patients.

The differences among them were noted however they were statistically insignificant with p value of 0.95.

DISTRIBUTION BASED ON MODE OF DELIVERY

Table11 – table showing distribution of patients according to mode of delivery



Graph 8 – Pie chart showing distribution of patient with regard to mode of delivery

It is observed from the above table that higher number of participants i.e., 127 (84.7%) among the total patients underwent lower segment C section and while only 23 (15.4%) delivered by FTVD.

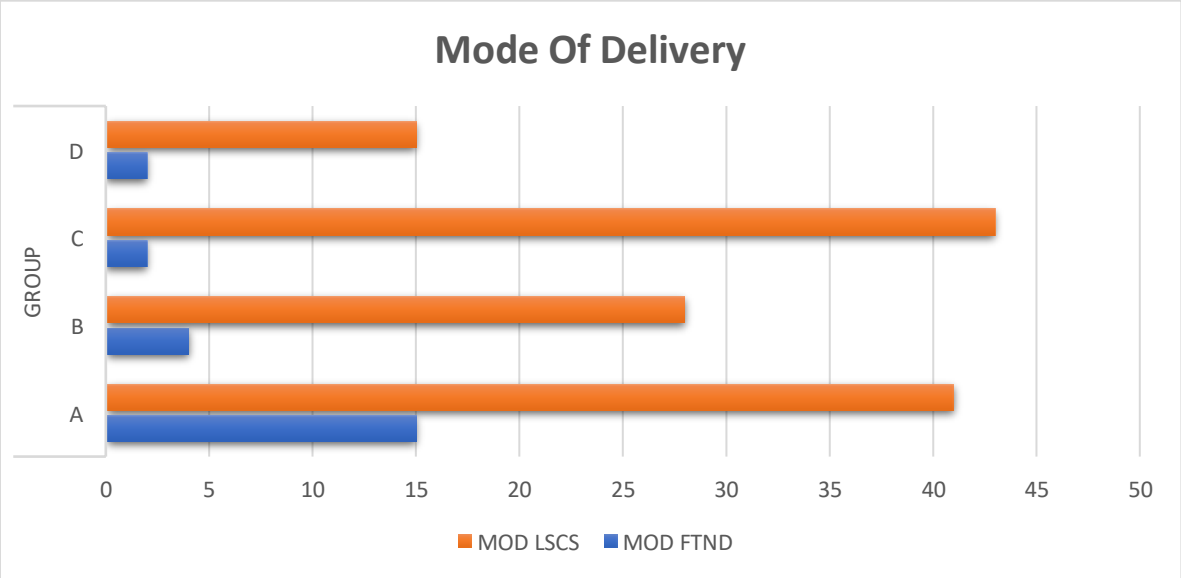
GROUP WISE DISTRIBUTION ACCORDING TO MODE OF DELIVERY

		MODE OF DELIVERY					P Value
		FTND	%	LSCS	%	Total	
GROUP	A	15	26.7%	41	73.2%	56	0.01*
	B	4	12.5%	28	87.5%	32	
	C	2	4.4%	43	95.5%	45	
	D	2	11.7%	15	88.3%	17	
Total		23		127		150	

Fisher's Exact Test * Statistically significant

Tabe 12- Table showing distribution of patients

ACCORDING TO MODE OF DELIVERY IN DIFFERENT GROUPS.



Graph 9 - Bar diagram showing distribution of patients

From the above tables it was noted that:

Group A (Normal Doppler Studies and Normal MBPP) - 41 among 56 patients delivered by LSCS (73.2%) as compared to 15 who delivered by FTVD (27%).

Group B (Abnormal Doppler studies and Normal MBPP)-28 among 32 patients delivered by LSCS (87.5%) as compared to 4 who delivered by FTVD (12.5%).

Group C (Normal Doppler studies and Abnormal MBPP)- 43 among 45 patients delivered by LSCS (95.5%) as compared to 2 who delivered by FTVD (4.4%).

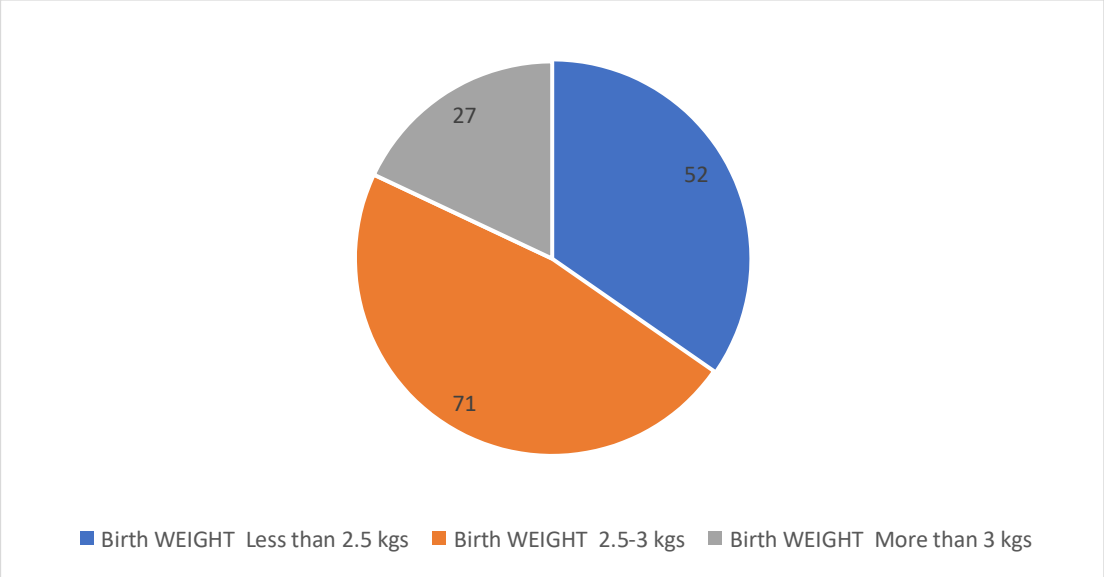
Group D (Abnormal Doppler studies and Abnormal MBPP)-15 among 17 patients delivered by LSCS (88.2%) as compared to 2 who delivered by FTVD (11.7%).

The differences among them were noted and were statistically significant with p value of 0.01.

DISTRIBUTION BASED ON BIRTH WEIGHT

		Frequency	Percent
Birth WEIGHT	Less than 2.5 kgs	52	34.7
	2.5-3 kgs	71	47.3
	More than 3 kgs	27	18.0
	Total	150	100.0

Table 13- Table showing distribution of patients with respect to birth weight.



Graph 10 – Pie chart showing distribution of patients according to birth weight in different groups.

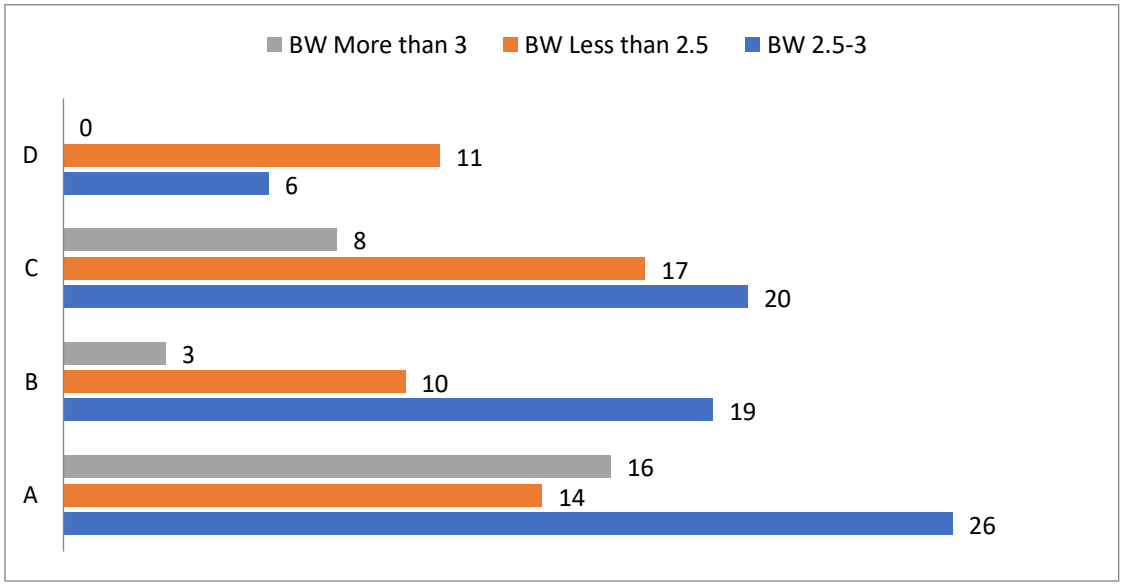
As seen from the above data maximum number of newborn were of the birth weight 2.5 to 3 kgs (47.3%)

DISTRIBUTION OF PATIENTS ACCORDING TO BIRTH WEIGHT IN GROUPS

		BIRTH WEIGHT			P Value
		Less than 2.5 kgs	2.5-3kgs	More than 3 kgs	
GROUP	A	14	26	16	0.02*
	B	10	19	3	
	C	17	20	8	
	D	11	6	0	
Total		52	71	27	

*Statistically significant

Table 14- Table showing distribution of patients with respect to birth weight in groups .



Graph 11 - Bar Diagram showing distribution of patients according to birth weight in different groups.

From the above tables it was noted that:

Group A (Normal Doppler Studies and Normal MBPP) - 26 among 56 newborn had a birth weight between 2.5 to 3 kgs. while 14 had LBW.

Group B (Abnormal Doppler studies and Normal MBPP)- 19 among 32 new born had a birth weight between 2.5 to 3 kgs. while 10 had LBW

Group C (Normal Doppler studies and Abnormal MBPP)- 20 among 45 new born had a birth weight between 2.5 to 3 kgs. while 17 had LBW

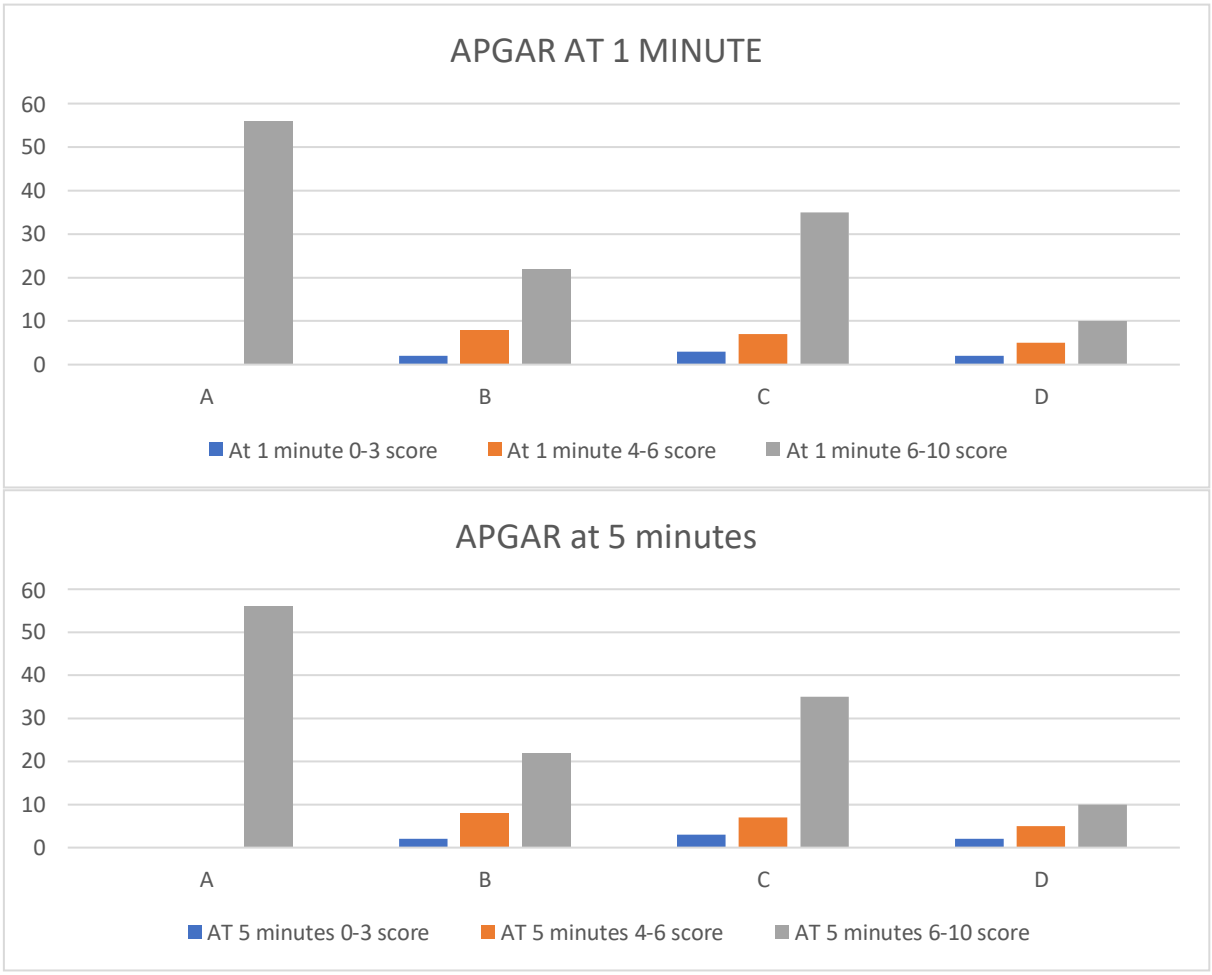
Group D (Abnormal Doppler studies and Abnormal MBPP)-11 among 17 newborn had a birth weight less than 2.5 kgs.

The differences among them were noted and were statistically significant with p value of 0.02

DISTRIBUTION BASED ON APGAR SCORE

GROUP	At 1 minute			At 5 minutes		
	0-3	4-6	6-10	0-3	4-6	6-10
A			56			56
B	2	8	22	2	8	22
C	3	7	35	3	7	35
D	2	5	10	2	5	10
P value – 0.01*						

Table 15- Table showing distribution of patients with respect to APGAR score.



Graph 12a - Bar Diagram showing distribution of patients according to APGAR score 1 minute in different groups. 12b - Bar Diagram showing distribution of patients according to APGAR score 5 minute in different groups.

From the above tables it was observed that:

Group A (Normal MPBPP and Normal Doppler studies) – 56 among 56 new born had an APGAR score above 6 measured at 1 and 5 minutes after birth (100%).

Group B (Abnormal Doppler studies and Normal MBPP) -22 among 32 new born had had an APGAR score above 6 measured at 1 and 5 minutes after birth (68.7), 8 new born had APGAR score of less than 6 (31.5 %)

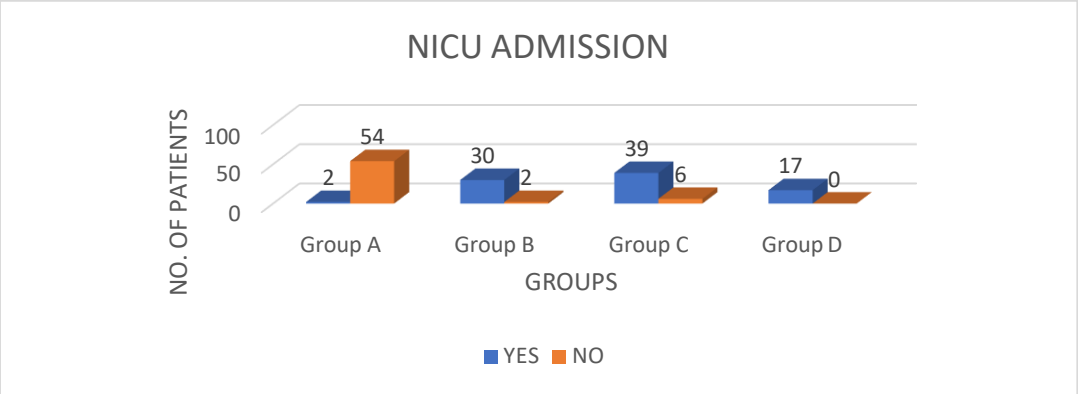
Group C (Normal Doppler studies and Abnormal MBPP) -35 among 45 new born had had an APGAR score above 6 measured at 1 and 5 minutes after birth (77.7%), 10 new born had APGAR score of less than 6 (22.2 %)

Group D (Abnormal Doppler studies and Abnormal MBPP) 10 among 17 new born had had an APGAR score above 6 measured at 1 and 5 minutes after birth (58.87),7 new born had APGAR score of less than 6 (41.5 %)

The differences among them were noted and were statistically significant with p value of 0.01.

GROUP WISE DISTRIBUTION BASED ON NICU ADMISSION

Table 16- Table showing distribution of patients with respect to NICU admission.



Graph 13 – Bar diagram showing distribution with respect to NICU admission.

From the above tables it was observed that:

Group A (Normal MPBPP and Normal Doppler studies) – 54 among 56 babies new born did not need NICU admission (96.4%).

Group B (Abnormal Doppler studies and Normal MBPP) -30 among 32 babies required NICU admission (93.75).

Group C (normal Doppler studies and Abnormal MBPP) - 39 among 45 newborn needed NICU admission (86.6%).

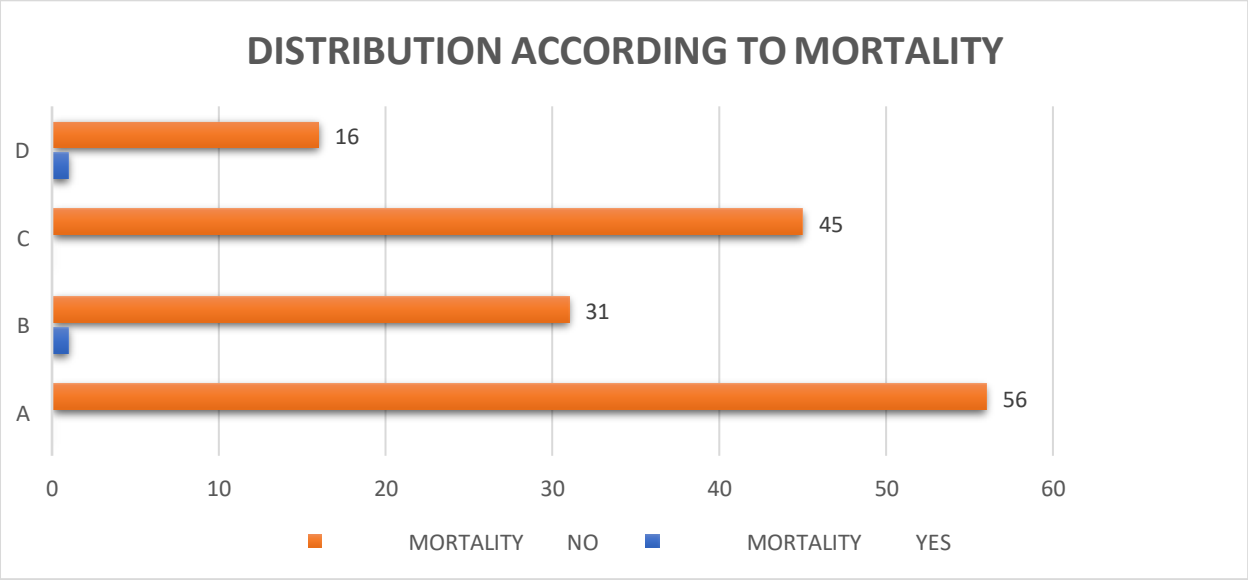
Group D (Abnormal Doppler studies and Abnormal MBPP) - 17 among 17 newborn needed NICU admission (100%).

The differences among them were noted and were statistically significant with p value of 0.01

GROUP WISE DISTRIBUTION BASED ON MORTALITY

		MORTALITY			P Value
		YES	NO	Total	
GROUP	A	0	56	56	0.001*
	B	01	31	32	
	C	0	45	45	
	D	01	16	17	
Total		2	148	150	

Table 17– Distribution of patient with respect to mortality



Graph 14- Bar diagram showing distribution with respect to mortality.

From the above tables it was observed that:

Group A (Normal MPBPP and Normal Doppler studies) –56 among 56 new born had no perinatal mortality (100%).

Group B (Abnormal Doppler studies and Normal MBPP) -1 among 32 newborn had perinatal mortality (3.1%)

Group C (normal Doppler studies and Abnormal MBPP) - 45 among 45 newborn no perinatal mortality (100%)

Group D (Abnormal Doppler studies and Abnormal MBPP) – 1 among 17 newborn had perinatal mortality (5.9%).

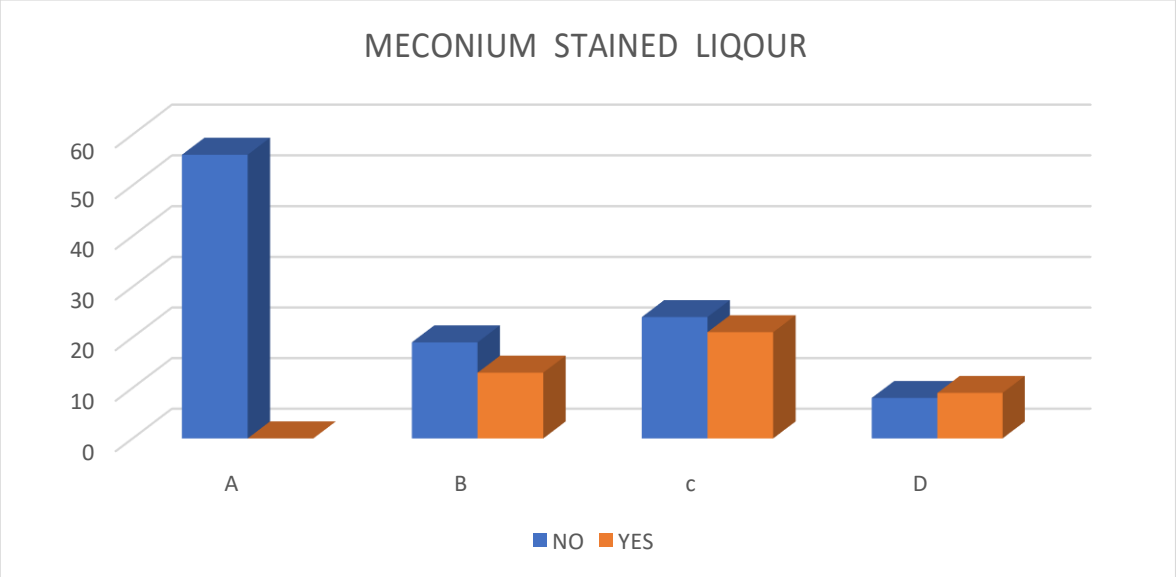
From the above tables it was observed that, among all groups Group B and Group D had 1 perinatal mortality in each group.

The differences among them were noted and were statistically significant with p value of 0.01

DISTRIBUTION BASED ON MECONIUM STAINED LIQUOUR.

		Liquor Status			P Value
		CLEAR	MSL	Total	
GROUP	A	56	0	56	0.001*
	B	19	13	32	
	C	24	21	45	
	D	08	9	17	
Total		95	55	150	

Table 18 – Distribution of patient according to meconium-stained liquor



Graph 15- Bar diagram showing distribution with respect to mortality.

From the above tables it was observed that:

Group A (Normal MPBPP and Normal Doppler studies)– among 56 patients no meconium-stained liquor (100%).

Group B (Abnormal Doppler studies and Normal MBPP) -among 32 patients, 13 had meconium-stained liquor (40.6%).

Group C (normal Doppler studies and Abnormal MBPP - among 45 patients, 21 had meconium-stained liquor (46.6%).

Group D (Abnormal Doppler studies and Abnormal MBPP) – among 17 patients, 9 had meconium-stained liquor (52.9%).

The differences among them were noted and were statistically significant with p value of 0.01

Comparison of MBPP with Doppler studies

In our study adverse perinatal outcome were measured in terms of the following factors**.**

- NICU admission

- Neonatal Outcome
- APGAR At 5 Minutes
- Fetal Distress Intrapartum
- Caesarean section due to fetal distress
- Resuscitation Required at Birth
- Meconium staining of liquor

Group wise Amniotic fluid Index measured before delivery

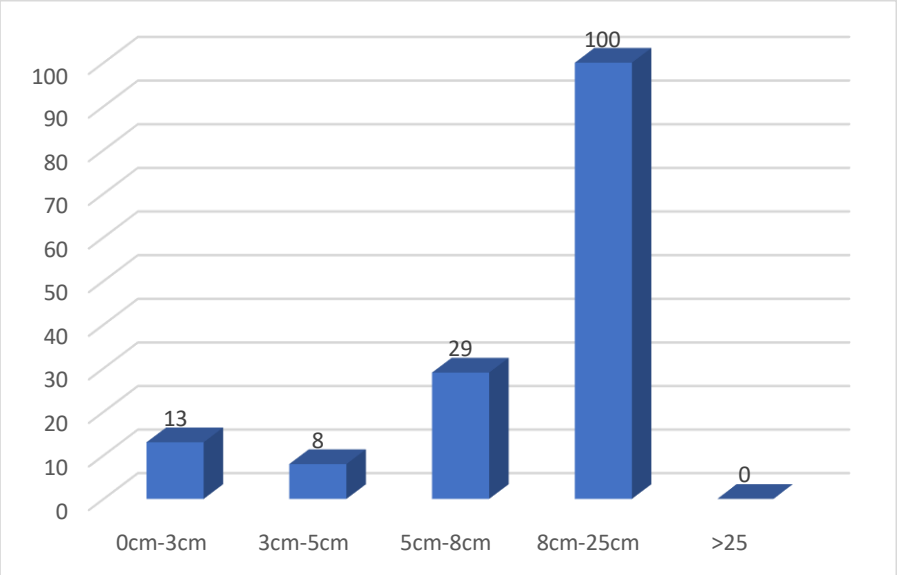
GROUP	LAST AFI BEFORE DELIVERY	
	Mean	Std deviation
A (Normal MBPP and normal Doppler)	12.2	3.03
B (Normal MBPP and Abnormal Doppler)	12.3	2.6
C (Abnormal MBPP and normal Doppler)	6.07	3.47
D (Abnormal MBPP and normal Doppler)	6.63	3.79

Table 19 – Mean of patients with respect to last measured AFI.

From the above table the Mean±SD of AFI among Group A (56 cases) were 12.3± 3.03. Mean±SD of AFI among Group B (32cases) were 12.3±2.6. The Mean±SD of AFI among Group C (45 cases) were 6.63± 3.47. Mean±SD of AFI among Group D (17 cases) were 6.63±3.79 and were statistically significant p of 0.003.

Amniotic fluid index	Number	Frequency
0-3	13	8.6%
3-5	8	5.3%
5-8	29	19.3%
8-25	100	66%
>25	0	0%

Table 20 – Table showing distribution of patients according to AFI.



Graph 16- Bar diagram showing distribution with respect to AFI.

From the above data it was observed that maximum patients had normal AFI 66% followed by 5cm to 8cm AFI 19.3% in our study groups.

Correlation of AFI with adverse perinatal outcome.

AMNIOTIC FLUID INDEX		NORMAL AFI n = 100		OLIGOHYDRAMINOUS n = 50		P value
NICU admission		44	44%	44	88%	0.001*
Neonatal Outcome	Healthy	56	56%	6	12%	0.001*
	IUGR	6	6%	12	24%	0.05*
	Neonatal death	0	0	2	4%	0.6
APGAR At 5 Minutes	0-3	3	3%	1	2%	0.545
	4-6	10	10%	8	16%	
	6-10	87	87%	41	82%	
Fetal Distress Intrapartum		23	23%	21	52%	0.02*
Low Birth Weight <2.5kgs		27	27%	16	32%	0.523
Caesarean due to fetal distress		17	17%	12	24%	0.306*
Resuscitation Required at Birth	Routine Care	56	56%	23	46%	0.0160*
	Bag and Mask	25	25%	7	14%	
	Intubation	19	19%	20	40%	
Neonatal Complications	Hypoglycaemia	3	3%	1	2%	0.001*
	Sepsis	2	2%	3	6%	
	MAS	18	18%	22	44%	
	RDS	9	9%	5	10%	
	TTN	9	9%	3	6%	
	Seizures	3	3%	10	20%	
Meconium stained liquour	Clear	81	81%	28	60%	0.0012*
	MSL	19	19%	22	40%	

Table 21- table showing the correlation of last measured AFI and perinatal outcome.

AFI (8cm to 25 cm)

- NICU admission -It was observed that 44 out of 100 new borns required -NICU admission (44%).
- Healthy new-borns -Among 100 new-born 56 were healthy.
- IUGR- 6 new-born had IUGR
- There was no perinatal outcome.
- 87 new-born had an APGAR of more than 6 measured at 1 and 5 minutes after birth 13 have low APGAR score less than 6.
- 77 new-born had no intrapartum fetal distress.

- 27 had low birth weight, 73 had birth weight above 2.5 kgs.
- 17 patients among 100 underwent LSCS due to fetal distress.
- 19 new-born required immediate intubation while 25 new born needed bag and mask ventilation while 56 required only routine new born care.
- Significant clear liquour 81 % was seen in cases of normal Amniotic Fluid Index.

OLIGOHYDRAMINOUS

- It was observed that 44 out of 50 (88%) new borns required NICU admission (44%) who had an AFI less than 8 cm.
- Among 50 newborn only 6 were healthy.
- 12 newborn had IUGR and there were 2 perinatal deaths.
- 41 newborn had an APGAR of more than 6 measured at 1 and 5 minutes after birth 9 have low APGAR score less than 6 (18%).
- 21 newborn had intrapartum fetal distress (52%).
- 16 had low birth weight while 29 had birth weight above 2.5 kgs. (58%)
- 12 patients among 50 underwent LSCS due to fetal distress (24%).
- 20 newborn (40%) required immediate intubation while 7 newborn needed bag and mask ventilation while 23 required only routine newborn care.
- Significant clear liquour was seen in cases of low Amniotic Fluid Index 28 patients (60%).

P value was significant for NICU admission, neonatal outcome, fetal distress, LBW C section due to festal distress, Resuscitation at birth, neonatal complications and Meconium-stained liquor when AFI was compared between normal and abnormal groups.

Distribution of patients with respect to last Non-Stress Test recorded before birth.

GROUPS	NST - ASSURING	FREQUENCY	NST- NON-ASSURING	FREQUENCY
A	56	100%	0	0
B	32	100%	0	0
C	19	42.1%	26	57.7%
D	05	29.4	12	70.5%

Table 22-Table distribution of patients with respect to last Non-Stress Test

It was observed that 112 patients had a reactive NST before delivery while 38 patients had non reassuring NST. The following tables correlate NST as a predictor of adverse perinatal outcome.

NON-STRESS TEST		Reactive NST n= 112		Non-Reactive NST n= 38		P value
NICU admission		52	46.4	36	94.7	<0.001*
Neonatal Outcome	Healthy	60	53	2	5.2	<0.001*
	IUGR	3	2.6	9	23	0.789
	Neonatal death	2	1.7	0	0	<0.005*
APGAR At 5 Minutes	0-3	6	5.3	1	2.6	0.730
	4-6	13	11	7	18	
	6-10	93	83	30	78	
Fetal Distress Intrapartum		34	27.8	27	71	<0.001*
Low Birth Weight <2.5kgs		30	30	16	42	0.07
Caesarean due to fetal distress		25	22	13	34.2	0.1454*
Resuscitation Required at Birth	Routine Care	60	53.5	6	15	0.0002*
	Bag and Mask	26	23.2	18	47	
	Intubation	26	23.2	14	36.8	
Neonatal Complications	Hypoglycaemia	2	1.7	2	2.4	<0.001*
	Sepsis	3	2	2	2.4	
	MAS	25	22.3	15	39	
	RDS	10	8.9	4	10	
	TTN	8	7.1	4	10	
	Seizures	4	3.5	9	23	
Meconium stained liqour	Clear	87	77.6	16	42.1	<0.001
	MSL	25	22.3	22	57	

Table 23- table shows the correlation of last measured AFI and perinatal outcome.

REACTIVE NST

- It was observed that 60 out of 112 (88%) new borns did not require NICU admission (53%) who had an assuring NST

- Among 112 new born 60 were healthy.
- 3 new born had IUGR and there were 2 perinatal deaths.
- 93 newborn had an APGAR of more than 6 measured at 1 and 5 minutes after birth 19 have low APGAR score less than 6 (16.3%).
- 34new born had intrapartum fetal distress (27.8%).
- While 82 had birth weight above 2.5 kgs. (73%)
- 25 patients among 112 underwent LSCS due to fetal distress (22%).
- 26 newborn (23.2%) required immediate intubation while 26 new born needed bag and mask ventilation
- while 60 required only routine new born care (53.5%).
- Significant clear liqueur was seen in cases of assuring NST 87 patients (77.6%).

NON-REACTIVE NST

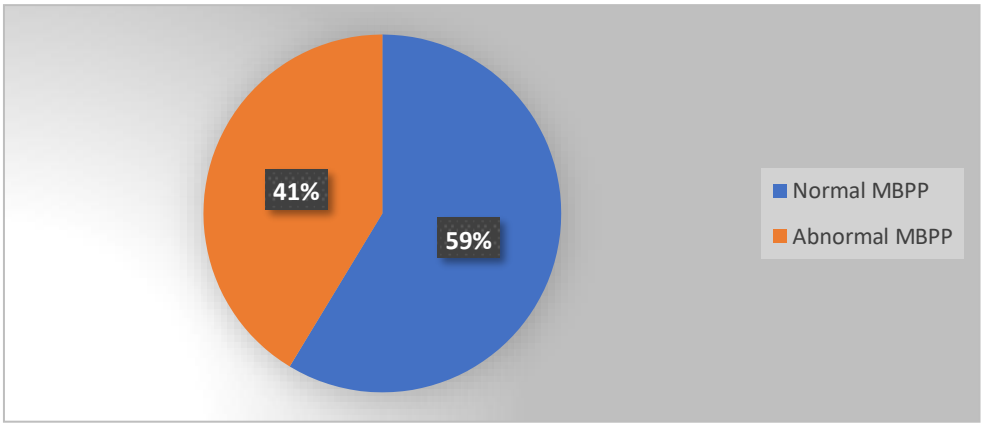
- It was observed that 36 out of 38 (94.7%) new borns required NICU admission who had a non-assuring NST.
- Among the 38 new born only 2 were healthy, 9 new born had IUGR and there were no perinatal deaths.
- 30 new born had an APGAR of more than 6 measured at 1 and 5 minutes after birth 8 have low APGAR score less than 6 (20.6%).
- 27 new born had intrapartum fetal distress (71 %) with non-reactive NST.
- 16 had low birth weight while 22 had birth weight above 2.5 kgs. (57%)
- 13 patients among 38 underwent LSCS due to fetal distress (34.2%).
- 14 new born (36.8%) required immediate intubation while 18 new born needed bag and mask ventilation while 6 required only routine new born care (15%).

- It was noted that meconium-stained liquor was the indication for NICU admission in 15 newborn (39%).
- Significant meconium-stained liqueur was seen in cases of non-assuring NST 22 patients (57%).

P value was significant for NICU admission, neonatal outcome, fetal distress, LBW, C section due to fetal distress, Resuscitation at birth, neonatal complications and Meconium-stained liquor when NST was compared between assuring and non-assuring groups.

MBPP as a predictor of adverse perinatal outcome

In our study it was observed that 88 had normal MBPP while 62 had abnormal MBPP. MBPP was considered abnormal if any of the following were abnormal AFI or NST.



Graph 17 – Pie chart showing distribution of patients according to MBPP.

Modified biophysical profile		NORMAL Total Number n=88 (%)		ABNORMAL N=62 (%)		P value
NICU admission		32	36.3	56	90.3	<0.001*
Neonatal Outcome	Healthy	56	84.8	6	9.6	0.001*
	IUGR	4	45.4	13	20.9	0.8
	Neonatal death	1	1.1	1	1.6	0.001*
APGAR At 5 Minutes	0-3	2	2.2	4	6.4	5.3
	4-6	8	9	12	19.3	
	6-10	78	88.6	46	74.1	
Fetal Distress Intrapartum		14	28	47	75.8	<0.001*
Low Birth Weight <2.5kgs		19	42	28	45.1	0.002*
Caesarean due to fetal distress		14	15.9	24	38.7	0.0016*
Resuscitation Required at Birth	Routine Care	60	68.1	6	9.6	0.001*
	Bag and Mask	15	17	26	41.9	
	Intubation	13	14.7	30	48.3	
Neonatal Complications	Hypoglycaemia	2	2.2	2	3.2	0.001*
	Sepsis	1	1.1	4	6.4	
	MAS	13	14.7	27	43.5	
	RDS	7	7.9	7	11.2	
	TTN	7	7.9	5	8	
	Seizures	2	2.2	11	17	
Meconium-staining liquor	Clear	75	85.2	32	51	0.001*
	MSL	13	14.7	30	48.3	

Table 24- table shows the correlation of MBPP and perinatal outcome.

NORMAL MBPP

- It was observed that 32 out of 88 (36.3%) new borns required NICU admission who had a normal MBPP. Among that 56 were healthy.
- 4 new born had IUGR and there was 1 perinatal death,78 new born had an APGAR of more than 6 measured at 1 and 5 minutes after birth 10 have low APGAR score less than 6 (11.2%).
- 14 newborn had intrapartum fetal distress (28%) with normal MBPP.
- 19 had low birth weight while 69 had birth weight above 2.5 kgs. (57%) 14 patients among 88 underwent LSCS due to fetal distress (15.9%).
- 13 newborn (14.7%) required immediate intubation while 15 new born needed bag and mask ventilation while 60 required only routine new born care (60.8%).
- It was noted that meconium-stained liquor was the indication for NICU admission in 13 newborn (14.7%).
- Significant clear liquor was seen in cases of normal MBPP 75 patients (85.2%)

ABNORMAL MBPP

- It was observed that 56 out of 62 (90.3%) new borns required NICU admission who had a abnormal MBPP.
- Among the 88 new-born 6 were healthy,13 new born had IUGR and there was 1 perinatal death.
- 46 new-born had an APGAR of more than 6 measured at 1 and 5 minutes after birth 16 have low APGAR score less than 6 (27.2%).
- 47 new-born had intrapartum fetal distress (75.8%) with abnormal MBPP .28 had low birth weight while 34 had birth weight above 2.5 kg (54.8%)
- 24 patients among 62 underwent LSCS due to fetal distress (39.7%).

- 30 new-born (48.3%) required immediate intubation while 26 new born needed bag and mask ventilation while only 6 required only routine new born care (9.6%).
- It was noted that meconium-stained liquor was the indication for NICU admission in 27 new-born (43.5%). And Clear liquor was seen in cases of abnormal MBPP 32 patients (48.3%).

P value was significant for NICU admission, neonatal outcome, fetal distress, LBW, C section due to fetal distress, Resuscitation at birth, neonatal complications and Meconium-stained liquor when MBPP was compared between normal and abnormal groups.

DOPPLER VELOCIMETYRY

Doppler studies were done on all 150 patients with high-risk pregnancy within 48 hours of delivery. Umbilical artery and MCA were studied

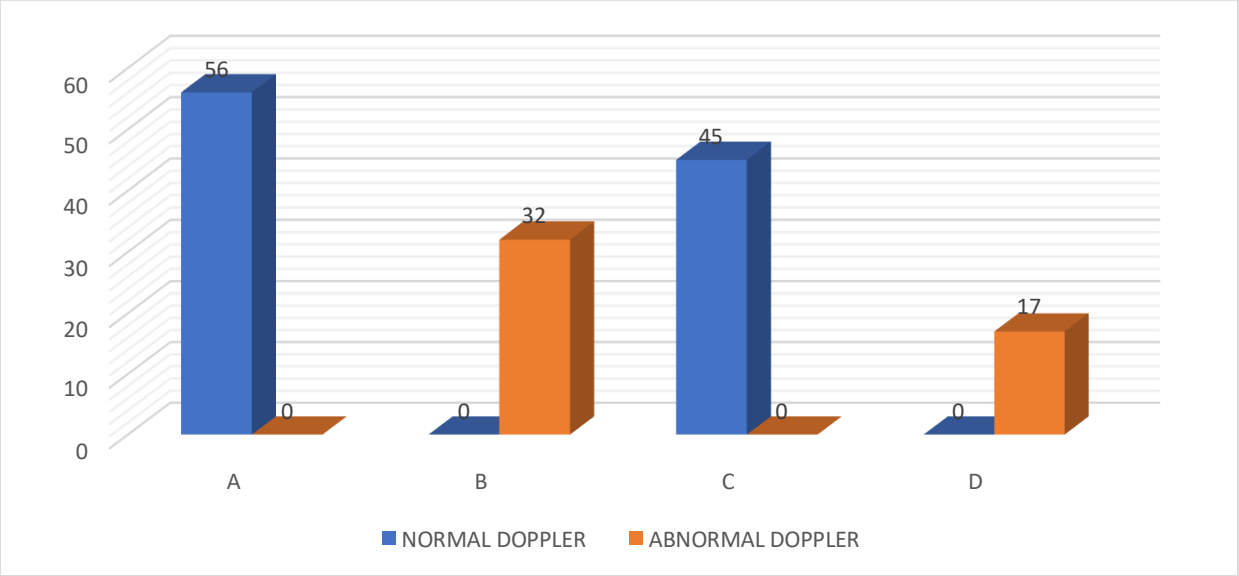
Doppler studies were considered abnormal if any one of the following were present

a. -RI of middle cerebral artery <5th percentile for the gestational age.
b. -Presence or absence of end diastolic flow or reversal of end diastolic flow in umblical artery.
c. -Presence of brain sparing effect in middle cerebral artery.

The following are the analysis of our study:

GROUP	NORMAL DOPPLER	FREQUENCY	ABNORMAL DOPPLER	FREQUENCY
A **(Normal MBPP and normal Doppler studies)**	56	37.3%	0	0
B **(Abnormal Doppler studies and Normal MBPP)**	0	0	32	21.3%
C **(Abnormal MBPP and normal Doppler studies)**	45	30%	0	0
D **(Abnormal Doppler studies and abnormal MBPP)**	0	0	17	11.3%

Table 25-table showing distribution of patient with respect to Doppler studies



Graph 18 – Bar diagram showing distribution of patients according to Doppler studies

Above table shows the number of patients with abnormal Doppler velocimetry in each of the 4 groups. Group B and Group D had 32 patients and 17 patients respectively.

Med±SD	GROUP A	GROUP B	GROUP C	GROUP D
Umb. Art S/D	2.39±0.47	2.56±1.09	2.42±0.71	2.46±1.05
Umb.Art PI	0.73±0.07	1.23±0.65	0.71±0.09	1.46±0.74
Umb. Art RI	0.51±0.05	0.67±0.20	0.52±0.06	3.11±9.71
MCA S/D	4.32±0.12	3.19±0.88	4.34±0.12	3.52±0.94
MCA PI	1.46±0.09	1.20±0.22	1.48±0.10	1.37±0.28
MCA RI	0.76±0.05	0.68±0.06	0.74±0.06	0.73±0.07

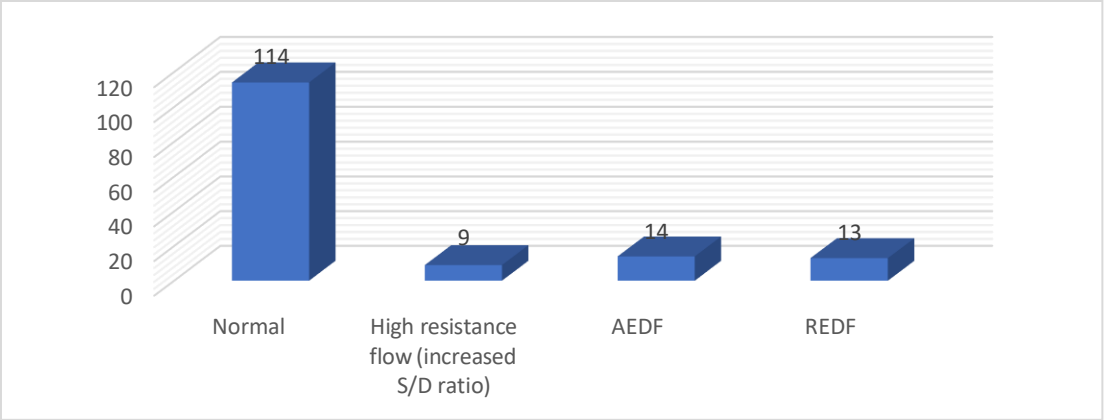
Table 26– mean and standard deviation with respect to Doppler studies

Umbilical artery flow pattern

Umbilical artery Doppler velocimetry was done in all 150 study participants the results were as follows:

Umbilical artery flow patterns	Number	Frequency
Normal	114	76%
High resistance flow (increased S/D ratio)	9	6%
AEDF	14	9.3%
REDF	13	8.6%

Table 27– Distribution of patients according to umbilical artery Doppler studies.



Graph 19 – Bar diagram showing distribution of patients according to umbilical artery Doppler studies.

114 patients out of 150 (76%) had normal Umbilical Artery Doppler studies. High resistance flow (increased S/D ratio) was seen in 9 out of 150 patients (6%). 14 patients had Absent end diastolic flow (9.3%) and 13 had Reversed end diastolic flow (8.6%).

Umbilical artery waveform		Normal n=114 Frequency (%)		Abnormal n= 36		P value
NICU admission		54	47.2	34	94.4	<0.001*
Neonatal Outcome	Healthy	60	52.6	2	5.5	<0.001*
	IUGR	7	6.1	10	27.7	0.8
	Neonatal death	1	0.8	1	2.7	0.001
APGAR At 5 Minutes	0-3	4	3.5	3	8.3	0.007*
	4-6	9	7.8	11	30.5	
	6-10	101	88.5	22	61.1	
Fetal Distress Intrapartum		42	36.8	19	52.7	0.003*
Low Birth Weight <2.5kgs		31	45.1	15	41.6	0.3*
Caesarean due to fetal distress		22	19.2	16	44.4	0.008*
Resuscitation Required at Birth	Routine Care	60	52.6	2	5.5	0.0034*
	Bag and Mask	31	27.1	13	36.1	
	Intubation	23	20.1	21	58.3	
Neonatal Complications	Hypoglycaemia	3	2.6	1	2.7	0.001*
	Sepsis	5	4.3	0	0	
	MAS	23	20.1	17	47.2	
	RDS	8	7.1	6	16.6	
	TTN	7	6.3	5	13.8	
	Seizures	8	7.1	5	13.8	
Meconium stained liquour	Clear	88	77.1	19	52.7	0.42*
	MSL	26	22.8	17	47.2	

Table 28– Umbilical artery Doppler studies and perinatal outcome

NORMAL UMBILICAL ARTERY WAVEFORM

- It was observed that 60 out of 114 (52.6 %) new borns did not require NICU admission who had normal Umbilical artery waveforms.
- Among the 114 new born 60 were healthy. 7 newborn had IUGR and there was 1 perinatal death.
- 101 newborn had an APGAR of more than 6 measured at 1 and 5 minutes after birth. while 13 have low APGAR score less than 6 (11.6%).
- 72 new born had no intrapartum fetal distress (71 %) with normal Umbilical artery waveform.
- 31 had low birth weight while 83 had birth weight above 2.5 kgs. (54.3%)
- 22 patients among 114 underwent LSCS due to fetal distress (19.2%).
- 23 newborn (20.1%) required immediate intubation while 31 new born needed bag and mask ventilation, While 60 required only routine newborn care (52.6%).
- it was noted that meconium-stained liquor was the indication for NICU admission in 23 newborn (20.1%). Significant clear liqueur was seen in cases of normal Umbilical Artery velocimetry 88 patients (77.1%).

ABNORMAL UMBILCAL ARTERY WAVEFORM

- It was observed that 34 out of 36(94.4 %) newborn required NICU admission who had abnormal Umbilical artery waveforms.
- Among the 36 newborn only 2 were healthy, 10 new born had IUGR and there was 1 perinatal death.
- 22 newborn had an APGAR of more than 6 measured at 1 and 5 minutes after birth. while 14 have low APGAR score less than 6 (39%).

- 19 new born had intrapartum fetal distress (52.7 %) with abnormal Umbilical artery waveform

  .

- 15 had low birth weight while 21 had birth weight above 2.5 kgs. (58.3%)
- 16 patients among 36 underwent LSCS due to fetal distress (52.7%)
- 21 new born (58.3%) required immediate intubation while 13 new born needed bag and mask ventilation while only 2 required only routine new born care (5.5%).
- It was noted that meconium-stained liquor was the indication for NICU admission in 17 new born (47.2%).
- Significant clear liqueur was seen in cases of normal Umbilical Artery velocimetry 19 patients (52.7%

  P value was significant for NICU admission, neonatal outcome, fetal distress, LBW, C section due to fetal distress, Resuscitation at birth, neonatal complications and Meconium-stained liquor when Umbilical artery Doppler was compared between abnormal and normal groups.

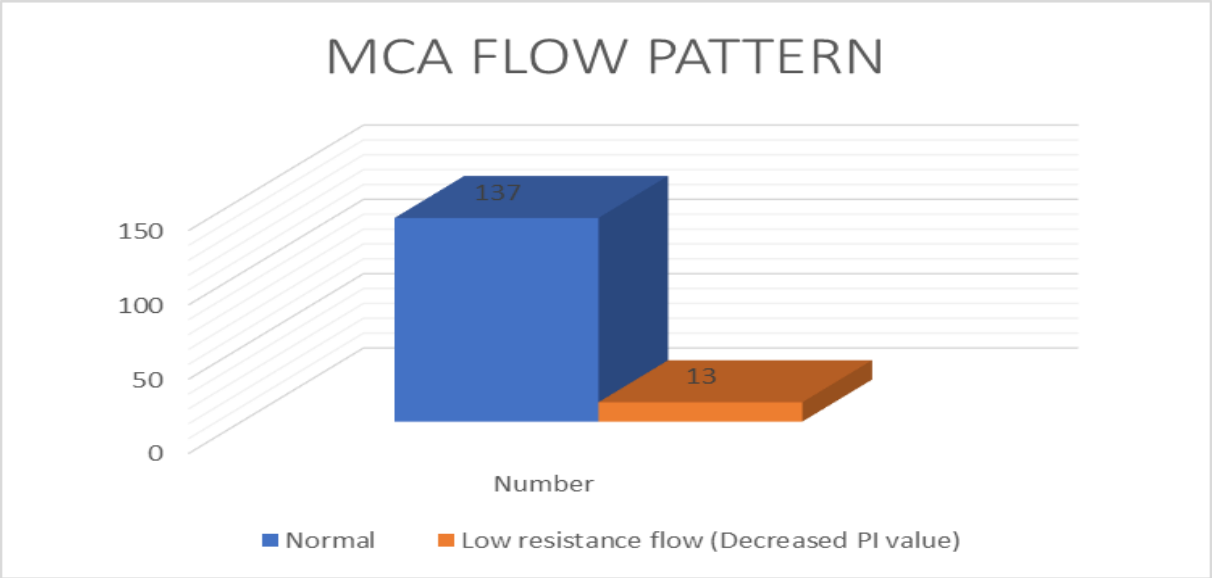
MCA Doppler velocimetry was done in all 150 study participants the results were as follows

		N	Mean	Std. Deviation	P Value
MCA	A	56.00	1.46	0.09	0.001*
	B	32.00	1.20	0.22	
	C	45.00	1.48	0.10	
	D	17.00	1.37	0.28	
	Total	150.00	1.40	0.19	

Table 29 – Mean and std. deviation of MCA Waveform

MCA flow patterns	Number	Frequency
Normal	137	91.3%
Low resistance flow (Decreased PI value)	13	8.6%

Table 30– Distribution of patients according to MCA Waveform



Graph 20 – Bar diagram showing distribution of patients according to MCA Doppler studies.

137 patients had normal MCA Doppler Studies, from which 13 had low resistance flow (8.6%).

MCA waveform		NORMAL n=137, (%)		ABNORMAL n = 13(%)		P value
NICU admission		75	54.7	13	100	0.0015*
Neonatal Outcome	Healthy	62	45.2	0	0	0.001*
	IUGR	15	10.9	2	15.3	0.7
	Neonatal death	1	0.7	1	7.6	0.001*
APGAR At 5 Minutes	0-3	6	4.3	0	0	0.53
	4-6	8	5.8	3	23.7	
	6-10	113	82.4	11	84.6	
Fetal Distress Intrapartum		54	29.1	7	53.8	0.33*
Low Birth Weight <2.5kgs		48	35	4	30.7	0.53
Caesarean due to fetal distress		32	23.3	6	46.1	0.008*
Resuscitation Required at Birth	Routine Care	62	45.2	0	0	<0.016*
	Bag and Mask	36	26.2	8	61.5	
	Intubation	39	28.4	5	38.4	
Neonatal Complications	Hypoglycaemia	4	2.9	0	0	0.0015*
	Sepsis	4	2.9	1	7.6	
	MAS	35	25.5	5	38.4	
	RDS	10	7.2	4	30.7	
	TTN	10	7.2	2	15.3	
	Seizures	12	8.7	1	7.6	
MSL	Clear	99	72.2	8	61.5	0.04*
	MSL	38	27.7	5	38.4	

Table 31- MCA Doppler studies and perinatal outcome

NORMAL MCA WAVEFORM

- It was observed that 75 out of 137 (54.7 %) new borns did not require NICU admission who had normal MCA waveforms.
- Among the 137 newborn 62 were healthy. 15 newborn had IUGR and there was 1 perinatal death.
- 113 new born had an APGAR of more than 6 measured at 1 and 5 minutes after birth.
- while 24 have low APGAR score less than 6 (10.3%). 54 new born had no intrapartum fetal distress (29.1 %) with normal MCA waveform .
- 48 had low birth weight while 89 had birth weight above 2.5 kgs. (64.9%)
- 32 patients among 137 underwent LSCS due to fetal distress (23.3%).

- 39 new born (28.4%) required immediate intubation while 36 new born needed bag and mask ventilation while 62 required only routine new born care (45.2%).
- It was noted that meconium-stained liquor was the indication for NICU admission in 35 new born (25.5%).
- Significant clear liqueur was seen in cases of normal Umbilical MCA velocimetry 99 patients (72.2%).

ABNORMAL MCA WAVEFORM

- It was observed that 13 out of 13 (100 %) new borns did not require NICU admission who had abnormal MCA waveforms.
- Among the 13 newborn none were healthy. 2 newborn had IUGR and there was 1 perinatal death.
- 11 newborn had an APGAR of more than 6 measured at 1 and 5 minutes after birth. while 3 have low APGAR score less than 6 (23.7%).
- 7 newborn had no intrapartum fetal distress (53.8%) with abnormal MCA waveform.
- 4 had low birth weight while 9 had birth weight above 2.5 kgs. (64.2%).
- 6 patients among 13 underwent LSCS due to fetal distress (46.1%).
- 5 newborn (38.4%) required immediate intubation while 8 new born needed bag and mask ventilation.
- It was noted that meconium-stained liquor was the indication for NICU admission in 5 newborn (38.4%). Significant clear liqueur was seen in cases of abnormal Umbilical MCA velocimetry 8 patients (61.5%).

P value was significant for NICU admission, neonatal outcome, C section due to fetal distress, Resuscitation at birth, neonatal complications, and Meconium-stained liquor for normal and Abnormal studies of MCA between both the groups.

Doppler velocimetry		NORMAL n=101		ABNORMAL N=49		P value
NICU admission		42	41.5	47	95.9	0.0020*
Neonatal Outcome	Healthy	69	68.3	2	4.8	0.001*
	IUGR	5	49.5	12	24.4	0.6
	Neonatal death	0	0	2	4.8	0.001*
APGAR At 5 Minutes	0-3	3	2.9	3	6.1	<0.001*
	4-6	7	6.9	13	26.5	
	6-10	91	90.9	33	67	
Fetal Distress Intrapartum		35	4.6	26	53	0.03*
Low Birth Weight <2.5kgs		31	30.6	18	36.7	0.4593
Caesarean due to fetal distress		16	15.8	22	44.8	0.001*
Resuscitation Required at Birth	Routine Care	60	59.4	2	4.8	<0.001*
	Bag and Mask	23	22.7	21	42.8	
	Intubation	18	17.8	26	53.06	
Neonatal Complications	Hypoglycaemia	3	2.9	1	2.04	<0.001*
	Sepsis	4	3.9	1	2.04	
	MAS	18	17.8	21	42.8	
	RDS	4	3.9	9	18.3	
	TTN	5	4.9	7	14.2	
	Seizures	7	6.9	6	12.2	
Meconium-stained liquor	Clear	80	79.2	27	55.1	0.002*
	MSL	21	20.7	22	44.8	

Table 32 –Table showing Doppler studies and perinatal outcome

NORMAL DOPPLER STUDIES

- It was observed that 42 out of 101 (41.5 %) new borns required NICU admission who had normal Doppler velocimetry.
- Among the 101 new born 69 were healthy. 5 newborn had IUGR and there was 1 perinatal death.
- 91 newborn had an APGAR of more than 6 measured at 1 and 5 minutes after birth.
- While 10 have low APGAR score less than 6 (10%). 35 newborn had no intrapartum fetal distress (34.6 %) with normal Doppler velocimetry.
- 31 had low birth weight while 70 had birth weight above 2.5 kgs. (69.3%).
- 16 patients among 101 underwent LSCS due to fetal distress (15.8%). 18 new born (17.8%) required immediate intubation while 23 new born needed bag and mask ventilation while 60 required only routine new born care (59.4%).
- It was noted that meconium-stained liquor was the indication for NICU admission in 18 newborn (17.8%).
- Significant clear liqueur was seen in cases of normal Doppler velocimetry 80 patients (79.2%).

ABNORMAL DOPPLER STUDIES

- It was observed that 47 out of 49 (95.9%) new borns required NICU admission who had abnormal Doppler velocimetry.
- Among the 49 newborn 2 were healthy. 12 newborn had IUGR and there were 2 perinatal deaths.
- 33 newborn had an APGAR of more than 6 measured at 1 and 5 minutes after birth.
- While 16 have low APGAR score less than 6 (32.6%). 26 newborn had intrapartum fetal distress (53%) with abnormal Doppler velocimetry.

- 18 had low birth weight while 31 had birth weight above 2.5 kgs. (63.2%) .26 patients among 101 underwent LSCS due to fetal distress (53%).
- 26 newborn (53.06%) required immediate intubation while 21 newborn needed bag and mask ventilation while 2 required only routine new born care (4.8%).
- It was noted that meconium-stained liquor was the indication for NICU admission in 21 newborn (42.8%).
- Significant clear liqueur was seen in cases of abnormal Doppler velocimetry 49 patients (55.1%).

P value was significant for NICU admission, neonatal outcome, fetal distress, C section due to fetal distress, Resuscitation at birth, neonatal complications, and Meconium-stained liquor for normal and Abnormal studies between both the groups.

COMPARISSON OF DOPPLER STUDIES VS MBPP VS COMBINED AS A PREDICTOR TO DETECT ADVERSE PERINATAL OUTCOME

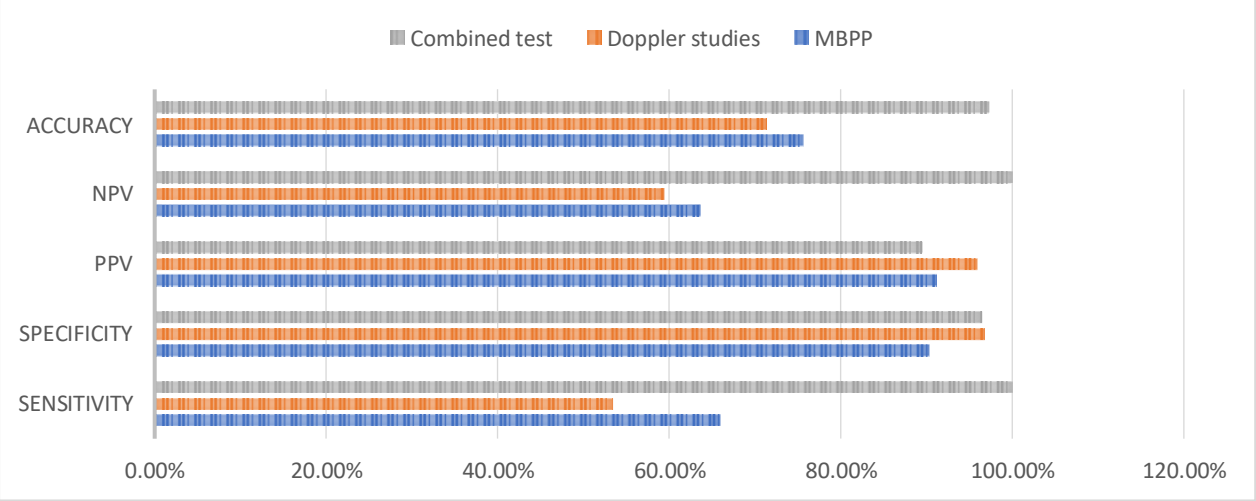
1. NICU ADMISSION

NICU admission	YES	NO	Total
MBPP	39	6	45
Doppler studies	30	2	32
Combined	17	0	17

Table 33–Table showing comparison of NICU admission

NICU ADMISSION	SENSITIVITY	SPECIFICITY	PPV	NPV	ACCURACY
MBPP	65.96%	90.32%	91.18%	63.64%	75.64%
Doppler studies	53.41%	96.77%	95.92%	59.41%	71.33%
Combined test	100.00%	96.43%	89.47%	100.00%	97.26%

Table 34 – NICU admission comparison



Graph 21 – Bar diagram of NICU admission

From the above table it was observed that combined methods of both MBPP and doppler studies was better as accuracy was 97.26% as a predictor for NICU admission in high-risk pregnancy following which MBPP as it had a higher Negative Predictive Value as compared to Doppler studies as a predictor for adverse perinatal outcome.

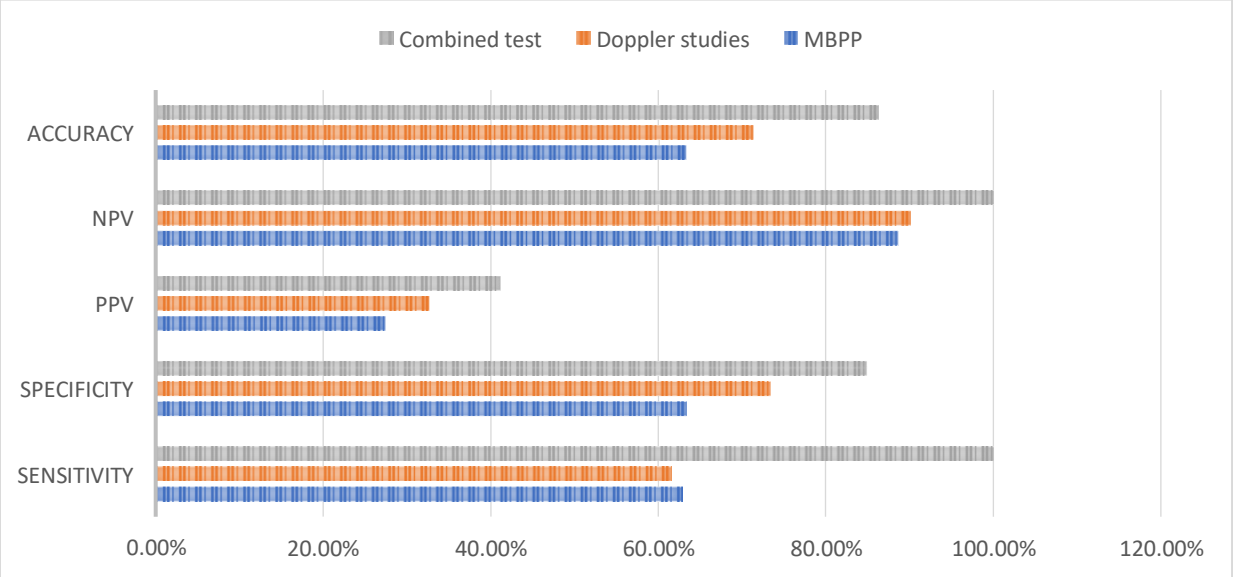
2. APGAR AT 1 AND 5 MINUTES AFTER BIRTH

Apgar at 1 and 5 minutes	<7	>7	Total
MBPP	10	35	45
Doppler studies	10	22	32
Combined	7	10	17

Table 35–Table showing comparison of APGAR score

APGAR At 1- and 5- Minutes score <7	SENSITIVITY	SPECIFICITY	PPV	NPV	ACCURACY
MBPP	62.96%	63.41%	27.42%	88.64%	63.33%
Doppler studies	61.54%	73.39%	32.65%	90.10%	71.33%
Combined test	100.00%	84.85%	41.18%	100.00%	86.30%

Table 36 –APGAR score comparison



Graph 22 -Bar diagram showing APGAR distribution

From the above table it was observed that combined methods of both MBPP and doppler studies was better with accuracy of 86.3% as a predictor for detecting low APGAR score in high-risk pregnancy following which Doppler studies was better as it had a higher Negative Predictive Value 90.10% as compared to MBPP as a predictor for adverse perinatal outcome.

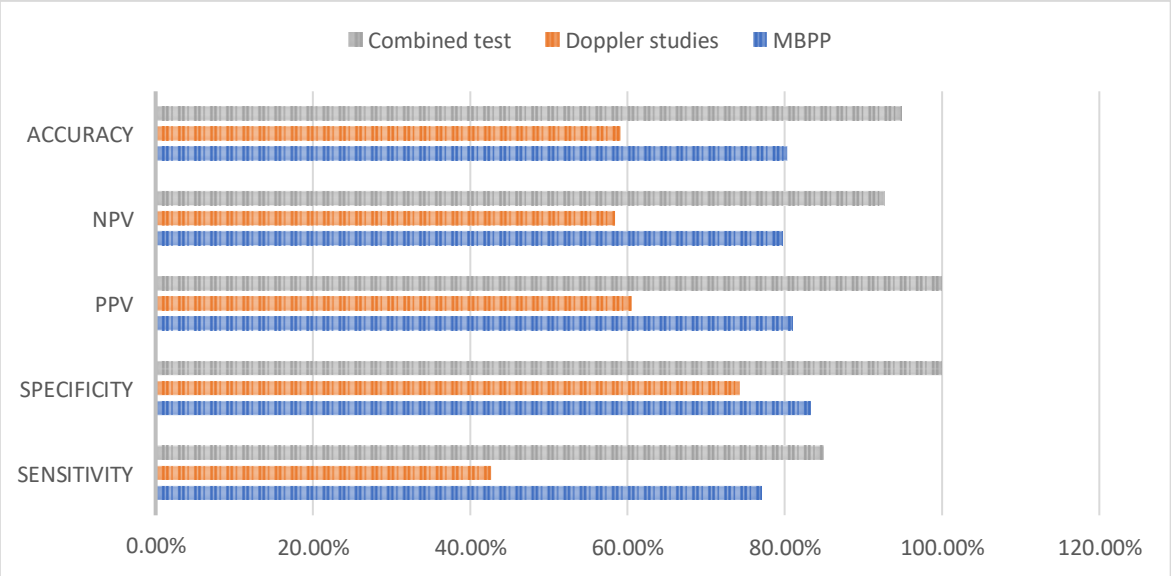
3.FETAL DISTRESS

Fetal distress	YES	NO	Total
MBPP	32	15	45
Doppler studies	11	21	32
Combined	15	2	17

Table 37–Table showing comparison of fetal distress

Fetal Distress I	SENSITIVITY	SPECIFICITY	PPV	NPV	ACCURACY
MBPP	77.05%	83.33%	81.03%	79.71%	80.31%
Doppler studies	42.62%	74.24%	60.47%	58.33%	59.06%
Combined test	85.00%	100.00%	100.00%	92.68%	94.83%

Table 38–Fetal distress comparison



Graph 23 -Bar diagram showing fetal distress distribution

From the above table it was observed that combined methods of both MBPP and doppler studies was better with accuracy of 94.83% as a predictor for detecting intrapartum fetal distress in high-risk pregnancy following which MBPP was better as it had a higher Negative Predictive Value 79.71% as compared to Doppler studies as a predictor for fetal Distress intrapartum.

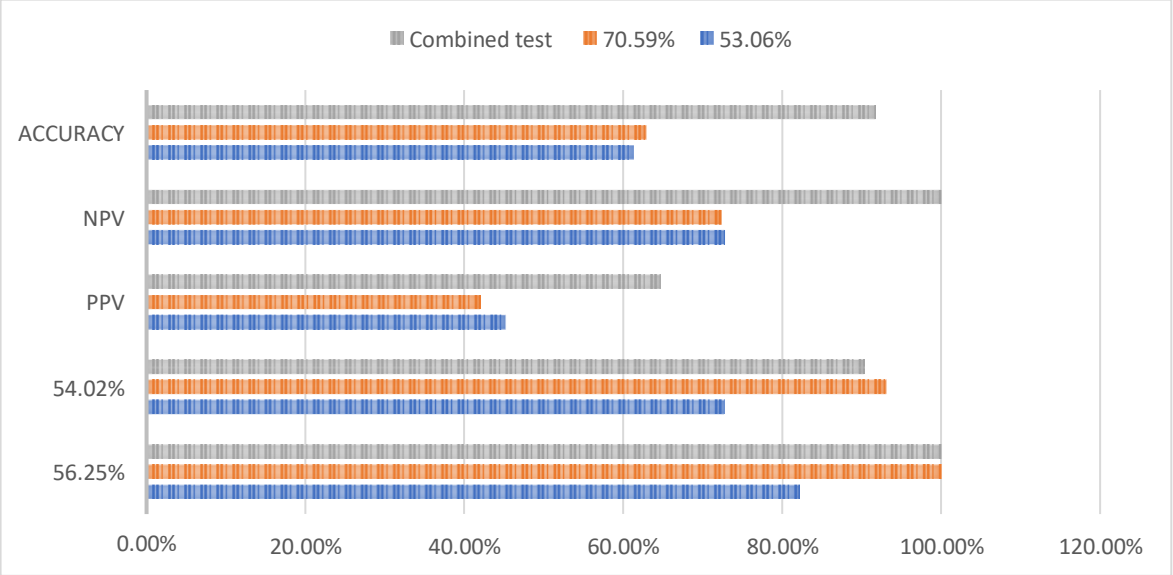
4.LOW BIRTH WEIGHT

Low Birth Weight	<2.5kgs	>2.5 kgs	Total
MBPP	17	28	45
Doppler studies	10	22	32
Combined	11	6	17

Table 39–Table showing comparison of low birth weight.

Birth Weight <2.5kgs	SENSITIVITY	SPECIFICITY	PPV	NPV	ACCURACY
MBPP	53.85%	65.31%	45.16%	72.73%	61.33%
Doppler studies	40.38%	73.64%	42.00%	72.32%	62.96%
Combined test	100.00%	90.32%	64.71%	100.00%	91.78%

Table 40 –Low birth weight comparison



Graph 24 -Bar diagram showing low birth weight distribution

From the above table it was observed that combined methods of both MBPP and doppler studies was better with accuracy of 91.78% as a predictor for detecting low birth weight in high-risk pregnancy following which Doppler studies was better as it had a higher accuracy 62.96% as compared to MBPP as a predictor for low birth weight.

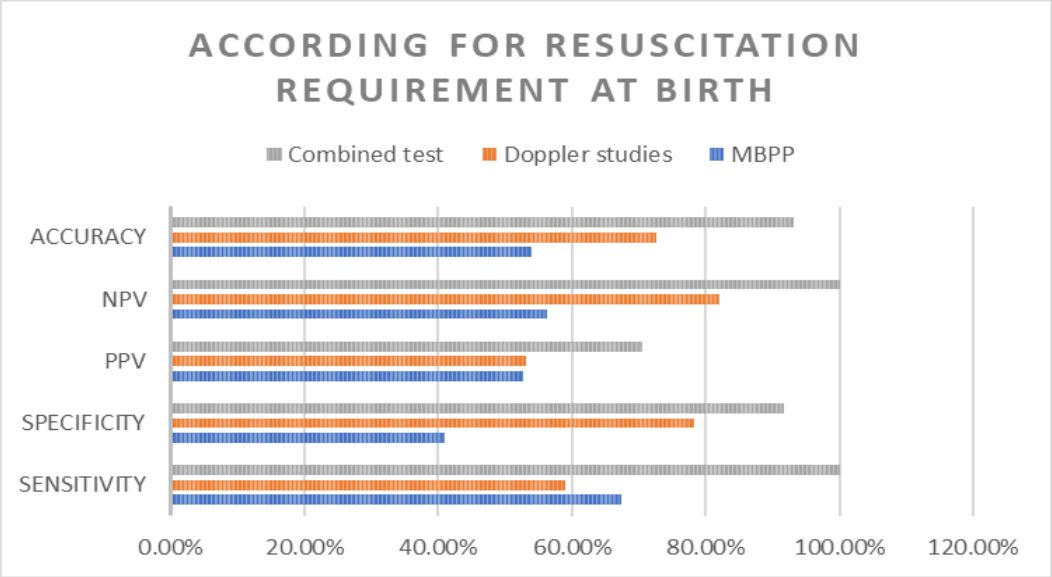
5.RESUSCITATION AT BIRTH

Resuscitation at birth	YES	NO	Total
MBPP	18	27	45
Doppler studies	14	28	32
Combined	12	5	17

Table 41–Table showing comparison of resuscitation at birth.

Resuscitation at birth	SENSITIVITY	SPECIFICITY	PPV	NPV	ACCURACY
MBPP	67.44%	40.91%	52.73%	56.25%	54.02%
Doppler studies	59.06%	78.30%	53.06%	82.18%	72.67%
Combined test	100.00%	91.80%	70.59%	100.00%	93.15%

Table 42 –Resuscitation at birth comparison



Graph 25 -Bar diagram showing resuscitation at birth distribution.

From the above table it was observed that combined methods of both MBPP and doppler studies was better with accuracy of 93.15% as a predictor for detecting need for resuscitation at birth in high-risk pregnancy following which Doppler studies was better as it had a higher accuracy 72.9% and negative predictive value of 82.18% as compared to MBPP as a predictor for neonatal resuscitation.

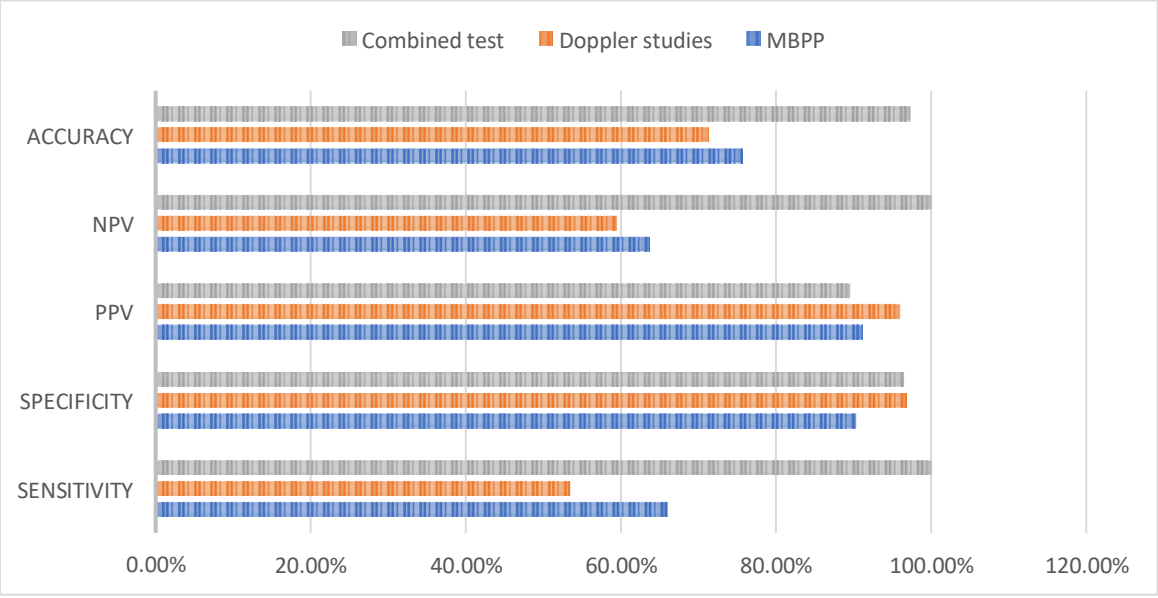
6.NEONATAL COMPLICATIONS

Neonatal complications	YES	NO	Total
MBPP	39	6	45
Doppler studies	30	2	32
Combined	17	0	17

Table 43–Table showing comparison of neonatal complications.

Neonatal Complications	SENSITIVITY	SPECIFICITY	PPV	NPV	ACCURACY
MBPP	65.96%	90.32%	91.18%	63.64%	75.64%
Doppler studies	53.41%	96.77%	95.92%	59.41%	71.33%
Combined test	100.00%	96.43%	89.47%	100.00%	97.26%

Table 44–Neonatal outcome comparison



Graph 26 -Bar diagram showing neonatal outcome distribution.

From the above table it was observed that combined methods of both MBPP and doppler studies was better with accuracy of 97.26% as a predictor for detecting neonatal complications at birth in high-risk pregnancy following which MBPP was better as it had a higher accuracy 75.6% and negative predictive value of 63.64% as compared to Doppler studies as a predictor for neonatal outcome.

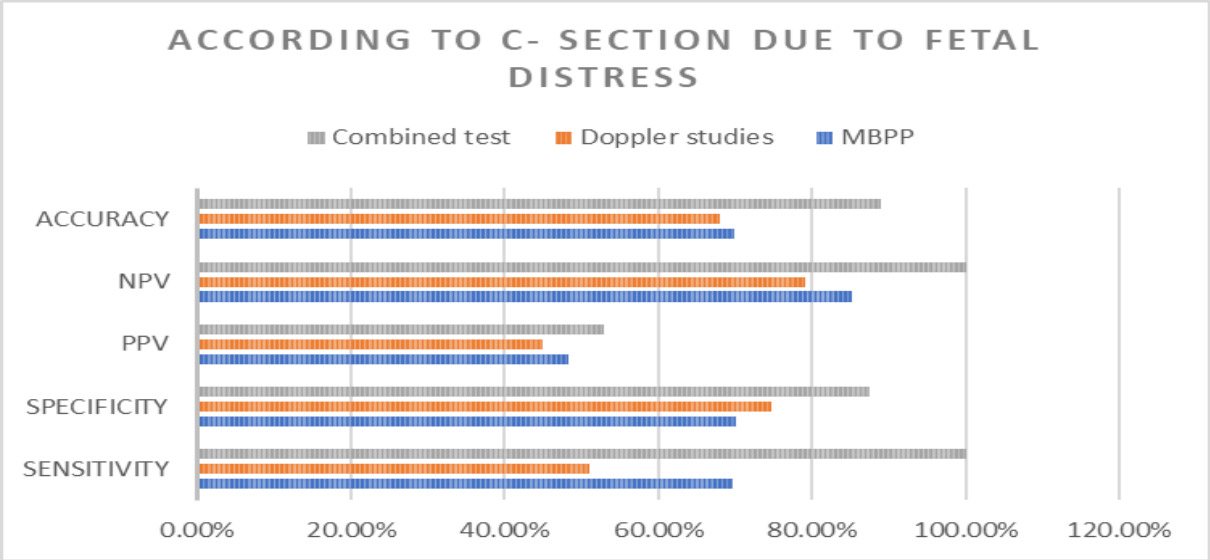
7. C SECTION DUE TO FETAL DISTRESS

C section due to fetal distress	YES	NO	Total
MBPP	13	32	45
Doppler studies	11	21	32
Combined	11	6	17

Table 45–Table showing comparison of C section due to fetal distress.

C section due to fetal distress	SENSITIVITY	SPECIFICITY	PPV	NPV	ACCURACY
MBPP	77.05%	83.33%	81.03%	79.71%	80.31%
Doppler studies	42.62%	74.24%	60.47%	58.33%	59.06%
Combined test	85.00%	100.00%	100.00%	92.68%	94.83%

Table 46- C section due to fetal distress compared.



Graph 27-Bar diagram showing C section due to fetal distress .

From the above table it was observed that combined methods of both MBPP and doppler studies was better with accuracy of 94.83% as a predictor for identifying patients that required C section for fetal distress in high-risk pregnancy following which MBPP was better as it had a higher accuracy 80.31% and negative predictive value of 79.71% as compared to Doppler studies as a predictor for identifying patients who required C section for fetal distress**.**

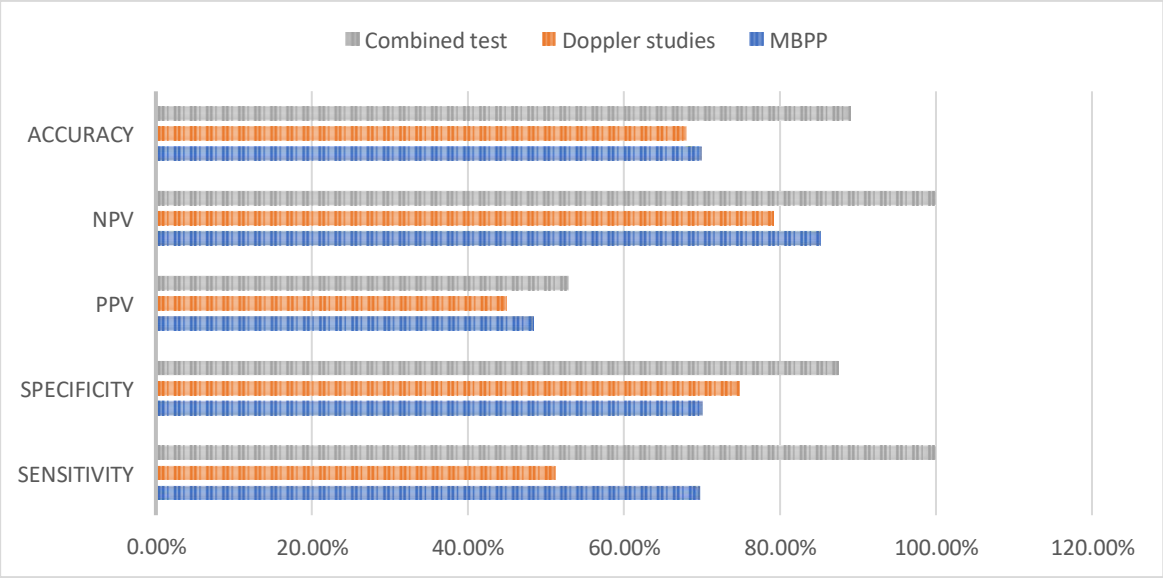
8. Staining of liquor

Liquor	MSL	Clear	Total
MBPP	21	24	45
Doppler studies	13	19	32
Combined	9	8	17

Table 47–Table showing comparison of meconium staining of liquour.

MSL	SENSITIVITY	SPECIFICITY	PPV	NPV	ACCURACY
MBPP	69.77%	70.09%	48.39%	85.23%	70.00%
Doppler studies	51.16%	74.77%	44.90%	79.21%	68.00%
Combined test	100.00%	87.50%	52.94%	100.00%	89.04%

Table 48–Meconium staining comparison



Graph 28-Bar diagram showing Meconium staining of liquor.

From the above table it was observed that combined methods of both MBPP and doppler studies was better with accuracy of 89.04% as a predictor for identifying patients with MSL in high-risk pregnancy following which MBPP was better as it had a higher accuracy 70% and negative predictive value of 85.23% as compared to Doppler studies as a predictor for identifying with MSL.

DISCUSSION

This research was conducted for one year and six months at BLDE (DU), Shri.B.M.Patil Medical College, Vijayapura, Karnataka, India. It was a prospective observational comparative study. 150 high risk patients were taken into this study which one or more high risk factor they were then subjected to both MBPP and doppler study with 48-72 hours irrespective of mode of termination and the perinatal outcome was observed, the results are as follows:

AGE GROUP

It was observed that a higher number of patients were below 25 years of age i.e.,102 (68%) in our study participant group this correlate with the study done by Kushboo et al., where comparison of modified biophysical profile and Doppler ultrasound in prediction of perinatal outcome in high-risk pregnancies was done in which the age group was 21- 25 years. But it is contast to studies of Dr. R.K. Talukdar et al., Mehmet Bardakci et al., Sonia H et al., and Kadir Bakay where the median age was 25 to 29 years.

Study	Age group in years (maximum incidence)
Present study	18-25 years
Dr. R.K. Talukdar et al.,	25-29 years
Mehmet Bardakci et al.,	25-29 years
Sonia H et al.,	21–30 years
Dr. Khushboo Malhotra et al.,	21 to 25 years
Kadir Bakay et al.,	21-30 years

Table 49- Comparison of various studies with respect to age group.

PARITY:

Here, most of the patients were multigravida n= 83 (55.3%), as compared to primigravida n= 67 (44.7%) which correlates with the study of Dr R.K. Talukdar and Dr. Khushboo Malhotra where more patients were multigravidas 58% and 59.33% respectively

Study	Primigravida%	Multigravida%
Present study	44.7	55.3
Dr. R.K. Talukdar et al.,	42%	58
Dr. Khushboo Malhotra et al.,	40.67%	59.33%

Table 50 -Comparison of various studies with respect to obstetric score.

MODE OF DELIVERY

Among 150 patients in our study more no. of patients underwent LSCS i.e.,127 (84.7%) as compared to FTVD (15.4%) this correlated with the study of Dr. R.K. Talukdar and Mehmet Bardakci et al. where the percentage of LSCS were higher i.e., 615 and 89.25 respectively. while our data is in contrast to the study of Sonia H where vaginal delivery was 58%, Dr, Kushboo Malhotra where vaginal delivery was 59.3% and Kadir Bakay where vaginal delivery was 79.8%. In our study the incidence of LSCS was high one of the reasons being the study was conducted in a tertiary care centre were most of the cases are refereed or unbooked cases with poor antenatal care.

Study	Vaginal delivery	LSCS
Present study	15.4 %	84.7 %
Dr. R.K. Talukdar et al.,	39%	61%
Mehmet Bardakci et al.,	10.8%	89.2%
Sonia H et al.,	58.00%	42%
Dr. Khushboo Malhotra et al.,	59.3 %	40%
Kadir Bakay et al.,	79.8%	20.2%

Table 51 -Comparison of various studies with respect to mode of delivery.

NICU ADMISSION

Here, most of the new born required NICU admission in our study 58.6% which was contradictory to the studies of Dr R.K. Talukdar, Dr. Khushboo Malhotra, Mehmet Bardakci et al.,Sonia H et al. and Kadir Bakay et al.,where majority of new borns did not require NICU admission majority of the new born required NICU admission for MSL . One of the main reasons for such high NICU admission is since most of the patients are referred cases, the late referral of patients only after complications have set in was a major factor.

Study	NICU ADMISSION	NO NICU ADMISSION
Present study	58.6%	41.4%
Dr. R.K. Talukdar et al.,	29%	71%
Mehmet Bardakci et al.,	6%	54%
Sonia H et al.,	23.6%	76.4%
Dr. Khushboo Malhotra et al.,	31.3%	68.7%
Kadir Bakay et al.,	24.2%	75.8%

Table 52- Comparison of various studies with respect to NICU admission.

APGAR SCORE

Our study was similar to the studies of Mehmet Bardakci et al.,Sonia H et al.,Dr. Khushboo Malhotra et al. and Kadir Bakay et al. where majority of the new born had an APGAR score of more than 7 measured at 1 and 5 minutes after birth . The data is summarized in the table below.

Study	<7	>7
Present study	18%	82%
Mehmet Bardakci et al.,	2.8%	97.2%
Sonia H et al.,	14.79%	85.3%
Dr. Khushboo Malhotra et al.,	13.6%	86.4%
Kadir Bakay et al.,	7.1%	92.9%

Table 53- Comparison of various studies with respect to APGAR score.

PERINATAL MORTALITY

Our study was similar to the studies of Mehmet Bardakci et al., Dr. R.K. Talukdar et al., Dr. Khushboo Malhotra et al. and Kadir Bakay et al. where percentage of perinatal mortality was low. Even though the incidence of NICU admission being high, since our hospital has a level 3 NICU facility the perinatal mortality is low.

The data is summarized in the table below

Study	YES	NO
Present study	1.3%	98.6%
Dr. R.K. Talukdar et al.,	5.3%	94.7%
Mehmet Bardakci et al.,	0.6%	99.4%
Dr. Khushboo Malhotra et al.,	4.2%	95.7%
Kadir Bakay et al.,	0	100%

Table 54-Comparison of various studies with respect to perinatal mortality.

MECONIUM STAINING LIQUOUR

Here, our study was similar to the studies of Mehmet Bardakci et al., Dr. Khushboo Malhotra et al., and Kadir Bakay et al., where liquor was clear in majority of the patients

Study	CLEAR	MSL
Present study	63.3%	36.6%
Mehmet Bardakci et al.,	95.6%	4.4%
Dr. Khushboo Malhotra et al.,	84.6%	15.3%
Kadir Bakay et al.,	91.9%	8.1%

Table 55- Comparison of various studies with respect to meconium staining of liquor.

Correlation between MBPP V/S Doppler study in predicting perinatal outcome

Out of 150 patients included in our study 88 new born were admitted in NICU, the sensitivity of MBPP was 65.96%, Specificity 90.32%, PPV 91.18%, NPV 63.64%and Accuracy was 75.64%. Which was more than that of Doppler studies where the Sensitivity was 53.41%, Specificity 96.77%, PPV 95.92%, NPV 59.41% and Accuracy was 71.33% However when both tests were done in combination the results improved and were as follows Sensitivity was 100.00%, Specificity 96.43%, PPV 89.47%, NPV 100.00% and Accuracy was 97.26% from which we can infer that combined test was a better predictor of NICU admission followed by MBPP followed by Doppler studies.

Coming to the prediction of low APGAR score the sensitivity of MBPP was 62.96%, Specificity 63.41%, PPV 27.42%, NPV 88.6%and Accuracy was 63.33%. Which was less than that of Doppler studies where the Sensitivity was 61.54%, Specificity 73.39%, PPV 32.65%, NPV 90.10% and Accuracy was 71.38% However when both tests were done in combination

the results were as follows Sensitivity was 100.00%, Specificity 84.45%, PPV 41.18%, NPV 100.00% and Accuracy was 86.30 % which clearly suggests that combined test was a better predictor of low APGAR score followed by Doppler studies followed by MBPP.

In our study for fetal distress the sensitivity of MBPP was 77.05%, Specificity 83.33%, PPV 81.03%, NPV 79.71%and Accuracy was 80.31%. Which was more than that of Doppler studies where the Sensitivity was 42.62%, Specificity 74.24%, PPV 60.47%, NPV 58.33% and Accuracy was 59.06% However when both tests were done in combination the results were as follows Sensitivity was 85%, Specificity 100%, PPV 100%, NPV 92.68 % and Accuracy was 94.83% from which we can infer that combined test was a better predictor of fetal distress followed by MBPP followed by Doppler studies.

Out of 150 patients included in our study 88 new born had neonatal complications/ adverse perinatal outcome. the sensitivity of MBPP was 65.96%, Specificity 90.32%, PPV 91.18%, NPV 63.64%and Accuracy was 75.64%. Which was more than that of Doppler studies where the Sensitivity was 53.41%, Specificity 96.77%, PPV 95.92%, NPV 59.41% and Accuracy was 71.33% However when both tests were done in combination the results were as follows Sensitivity was 100.00%, Specificity 96.43%, PPV 89.47%, NPV 100.00% and Accuracy was 97.26% from which we can infer that combined test was a better predictor of adverse perinatal outcome followed by MBPP followed by Doppler studies

ADVERSE PERINATAL OUTCOME

MBPP	SENSITIVITY	SPECIFICITY	PPV	NPV
Present study	65.96%	90.32%	91.18%	63.64%
Mehmet Bardakci et al.,	60 %	87.1%	24%	97%
Sonia H et al.,	62.5	74.41	43.1	86.48
Dr. Khushboo Malhotra et al.,	90.62%	56.98%	61.05%	89.09%
Kadir Bakay et al.,	94.11	89.2	94.11	98.7

Table 56a-Comparison of MBPP with various studies

DOPPLER STUDIES	SENSITIVITY	SPECIFICITY	PPV	NPV
Present study	53.41%	96.77%	95.92%	59.41%
Mehmet Bardakci et al.,	50	91.8	29.4	96.5
Sonia H et al.,	37.5	98.89	78.9	83.33
Dr. Khushboo Malhotra et al.,	88.33%	53.33%	55.79%	87.27%
Kadir Bakay et al.,	94.12	95.12	80	98.73

56b- Comparison of Doppler studies with various studies

COMBINED	SENSITIVITY	SPECIFICITY	PPV	NPV
Present study	100.00%	96.43%	89.47%	100.00%
Mehmet Bardakci et al.,	70	83.7	22.5	97.6
Sonia H et al.,	73.52	92.59	71.4	93.28
Dr. Khushboo Malhotra et al.,	96.87%	45.76%		
Kadir Bakay et al.,	100	89.2	65.38	100

56c- Comparison of combined studies with various studies

Our study had similar results with the study of Mehmet Bardakci et al.,Sonia H et al., Dr. Khushboo Malhotra et al. and Kadir Bakay et al. where combined (MBPP+Doppler studies) was a better predictor of adverse perinatal outcome where the NPV was higher than when MBPP and Doppler studies done alone . after which it was seen that MBPP had better prediction value of adverse perinatal outcome as compared to Doppler studies.

CONCLUSION

The main aim of this study was to compare the methods of fetal surveillance i.e the Doppler velocimetry and MBPP to precisely predict the perinatal outcome in High-Risk Pregnancies.

Perinatal outcome can be predicted by using MBPP and Doppler studies. For both the criteria, the sensitivity, specificity, positive predictive value, and negative predictive value are all reliable.

It was found that an abnormal Doppler study with abnormal MBPP is associated with an adverse perinatal outcome than when only one of the above was abnormal. The incidence of premature induction, caesarean section for fetal distress, low APGAR, NICU admissions and need for ventilation were more in cases in which both these tests were abnormal. Hence by combining the two, and acting appropriately, the incidence of adverse perinatal outcome may be reduced.

Out of both the parameters MBPP showed a better role in predicting perinatal outcome, MBPP can be performed as a standard screening technique to detect adverse perinatal outcome in term gestation especially in high-risk cases. Doppler studies though being good especially as a predictor of sudden detoriation in IUGR and also placental status assessment should not be used alone and is not a primarly tool of antenatal surveillance for high or low risk pregnancies.

MBPP helps reduces the adverse outcome by intervention at the early stages which will improve the outcome of pregnancy.

SUMMARY

150 pregnant women with term gestation and one additional high-risk factor who were admitted to the obstetrics and gynecology unit at the BLDE Shri. B. M. Patil Medical College Hospital and Research Institute in Vijayapura, Karnataka, India, were included in this study. The study was conducted between December 1, 2021, and June 20, 2022.

Only those patients who gave their consent were included in this study.

No matter the mode of delivery, modified Biophysical Profile and Doppler investigations were done on these individuals within 48 -72 hours of delivery.

Based on these findings, the patients were subsequently divided into the following 4 groups:

Normal MBPP and Doppler investigations make up Group A.

Normal MBPP and abnormal Doppler investigations constitute up Group B.

Group C-Normal Doppler studies and abnormal MBPP

Doppler studies with abnormal group D

Perinatal outcome was assessed based on factors such as APGAR at birth, NICU admission, prognosis, resuscitation at birth, fetal distress, and perinatal mortality.

In this study Pregnancy induced hypertension was a major risk factor for 60 patients out of 150 study participants (40%) followed by anemia 33 patients (22%). It was also noted that multigravidas were more as compared to primigravida in our study (55.3%).

With respect age group it was observed that most of the patients were of younger age group <25 years, 83 patients (56.33%) this could be attributed to the fact majority patient visiting our hospital are of low socio-economic status.

In our study 127 patients underwent LSCS (84.7%) as compared to FTVD. While comparing to group wise distribution Group C (abnormal MBPP and Normal Doppler) 95.5% underwent LSCS, Group D (abnormal Doppler and abnormal MBPP) 88.3% patients underwent LSCS, Group A where both the tests were normal 73.2% of the patients underwent LSCS.

Out of 150 patients 52 patients gave birth to babies which were LBW (3.7%) while rest newborn was above 2.5 kgs. From which greatest incidence was seen in group D where both tests were abnormal 11 out of 17 babies had LBW (64.7%).

Coming to APGAR score it was noted that in group A where both tests were normal 56 out of 56 newborns had APGAR score of more than 7 measured at 5 minutes (100%). While in group D where both tests were abnormal, 7 out of 17 had low APGAR score (41.17%).

In our study it was observed that 88 newborns required NICU admission (58.6%) and it also noted that 17 out of 17 in group D required NICU admission (100%). This showed that when both tests were abnormal there was an increased incidence of NICU admission.

From the 88 newborn who required NICU admission 2 had mortality (2.27%).

Out of 150 patients included in our study 88 new born had neonatal complications/ adverse perinatal outcome. the sensitivity of MBPP was 65.96%, Specificity 90.32%, PPV 91.18%, NPV 63.64%and Accuracy was 75.64%. Which was more than that of Doppler studies where the Sensitivity was 53.41%, Specificity 96.77%, PPV 95.92%, NPV 59.41% and Accuracy was 71.33% However when both tests were done in combination the results were as follows Sensitivity was 100.00%, Specificity 96.43%, PPV 89.47%, NPV 100.00% and Accuracy was 97.26% from which we can infer that combined test was a better predictor of adverse perinatal outcome followed by MBPP followed by Doppler studies in our study group

LIMITATION

The main limititaion faced in the study was to get Doppler studies in order to shift patients to scan room which was at a distance of 250 metres from our labour room as most patiens that were high hisk were not stable.

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The Constituent College

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

INSTITUTIONAL ETHICAL CLEARANCE CERTIFICATE

The Institutional ethical committee of this college met on 11-01-2021 at 11-00 am to scrutinize the synopsis of Postgraduate students of this college from Ethical Clearance point of view. After scrutiny the following original/corrected and revised version synopsis of the Thesis has been accorded Ethical Clearance

Title: Comparison of modified biophysical profile and Doppler ultrasonography studies in predicting perinatal outcome

Name of PG student: Dr Eldrida Theresa Fernanades
Department of Obst/Gynaec

Name of Guide/Co-investigator: Dr S R Mudanur, Professor & HOD of Obst/Gynaec

DR .S.V.PATIL
CHAIRMAN, IEC
Institutional Ethical Committee
B L D E (Deemed to be University)
Shri B.M. Patil Medical College,
VIJAYAPUR-586103 (Karnataka)

Following documents were placed before Ethical Committee for Scrutinization:

1. Copy of Synopsis / Research project
2. Copy of informed consent form
3. Any other relevant documents.

1

PROFORMA

"Comparison of modified biophysical profile and doppler ultrasonography studies in predicting perinatal outcome in high-risk pregnancies"

NAME:
AGE:
IN PATIENT NUMBER (I.P No.):
DATE OF ADMISSION:
ADDRESS :

PHONE NUMBER:
L.M.P (LAST MENSTRUAL PERIOD) :
P.O.G (PERIOD OF GESTATION) :
E.D.D (EXPECTED DATE OF DELIVERY):
MENSTRUAL HISTORY :
MARITAL HISTORY :

OBSTETRIC HISTORY:

PAST HISTORY:

HIGH RISK FACTORS:

PERSONAL HISTORY:

PROVISIONAL DIAGNOSIS:

GENERAL PHYSICAL EXAMINATION:

PALLOR: TEMPERATURE: PULSE: BLOOD PRESSURE:

CARDIOVASCULAR SYSTEM:

RESPIRATORY SYSTEM:

PER ABDOMEN:

PRESENTATION:

INVESTIGATIONS:

CBC:

Haemoglobin-

Total count-

Platelet count -

BLOOD GROUP:

RH TYPING-

OTHERS:

DOPPLER STUDY :

MCA: P/I Value: R/I Value: S/D Ratio:

Uterine Artery: P/I Value: R/I Value: S/D Ratio:

Umbilical Artery: P/I Value: R/I Value: S/D Ratio:

Modified bio physical profile

a) AFI:

b) NST: ASSURING /NON-ASSURING

DATE OF DELIVERY:

MODE OF DELIVERY:

BIRTH WEIGHT:

SEX OF BABY:

APGAR SCORE: at 1 minute -

At 5 minutes -

AT 10 minutes -

NICU ADMISSION: YES /NO:

DAYS OF ADMISSION IN NICU:

NASAL PRONGS/O2/CPAP/HFNC:

DAYS OF ADMISSION OF THE BABY IN HOSPITAL:

CONSENT FORM

B.L.D.E. (DEEMED TO BE UNIVERSITY) SHRI B.M. PATIL MEDICAL COLLEGE HOSPITAL AND RESEARCH CENTER, VIJAYAPURA-586103

INFORMED CONSENT FOR PARTICIPATION IN DISSERTATION/RESEARCH I, the undersigned,_____, D/O _____, aged_____years,

ordinarily resident of_____do hereby state/declare that Dr.ELDRIDA THERESA FERNANDES of Shri. B. M dissertation/research titled **"COMPARISON OF MODIFIED BIOPHYSICAL PROFILE AND DOPPLER ULTRASONOGRAPHY STUDIES IN PREDICTING PERINATAL OUTCOME IN HIGH RISK PREGNANCIES"**

Under the guidance of Dr. S.R MUDANUR requesting my participation in the study. Apart from routine treatment procedure, the pre-operative, operative, post-operative and follow-up observations will be utilized for the study as reference data. Doctor has also informed me that during conduct of this procedure like adverse results may be encountered. Among the above complications most of them are treatable but are not anticipated hence there is chance of aggravation of my condition and in rare circumstances it may prove fatal in spite of anticipated diagnosis and best treatment made available. Further Doctor has informed me that my participation in this study would help in evaluation of the results of the study which is useful reference to treatment of other similar cases in near future, and also I may be benefited in getting relieved of suffering or cure of the disease I am suffering.

The Doctor has also informed me that information given by me, observations made

photographs video graphs taken upon me by the investigator will be kept secret and not

assessed by the person other than me or my legal hirer except for academic purposes.

The Doctor did inform me that though my participation is purely voluntary, based on information given by me, I can ask any clarification during the course of treatment / study

related to diagnosis, procedure of treatment, result of treatment or prognosis. At the same Shri B.M.Patil Medical College Hospital and Research Centre has examined me thoroughly

on_____at_____(place) and it has been explained to me in my own

language that I am suffering from_____disease (condition) and this

disease/condition mimic following diseases. Further Dr ELDRIDA

FERNANDES informed me that he/she is conducting

time I have been informed that I can withdraw from my participation in this study at any time

if I want or the investigator can terminate me from the study at any time from the study but not the procedure of treatment and follow-up unless I request to be discharged.after understanding the nature of dissertation or research, diagnosis made, mode of

treatment, I the undersigned Smt_____under my full conscious state of mind agree to participate in the said research/dissertation.

Signature of patient:

Signature of doctor:

Date:

Place

MASTER CHART

20BMOBG011-ELRIDA-COMPARISON OF MODIFIED BIOPHYSICAL PROFILE AND DOPPLER ULTRASONOGRAPHY STUDIES IN PREDICTING PERINATAL OUTCOME IN HIGH-RISK PREGNANCIES

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