

Study of Triple Vessel Wave Pattern by Doppler Studies in Low Risk and High Risk Pregnancies and Perinatal Outcome

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Abstract

Objectives: Role of Triple vessel umbilical, middle cerebral and uterine artery wave pattern by colour Doppler study in low and high risk pregnancies in relation to perinatal outcome.

Methods: Fifty (50) patients with gestational age between 31-40 weeks who were diagnosed to have severe preeclampsia, preeclampsia with IUGR were studied and subjected to colour Doppler ultrasonography. Findings of Doppler studies were correlated with the following adverse Perinatal outcomes; Perinatal deaths, Emergency CS for foetal distress, Low Apgar score (5 min Apgar <7), and admission to NICU for complications of low birth weight. Pregnancy outcome was considered to be Uneventful or Favourable when the above complications were absent. The uterine artery, Umbilical artery and the Middle cerebral artery Doppler indices for the corresponding gestational age were compared with the reference values. The uterine artery and Umbilical artery Doppler indices were considered abnormal if the value was above the 95th percentile of previously published values for gestational age. The Middle cerebral artery Doppler index was considered abnormal if the value was below the 5th percentile of previously published values for gestational age. A single cut off value (1.08) was used for Cerebroplacental Ratio (MCA PI/UAPI), above which the cerebroplacental ratio was considered normal and below which it was considered abnormal.

Results: Acceptable wave forms were obtained from Uterine artery, MCA and UA in all these cases. All the cases were followed up for the perinatal outcome. Cerebroplacental ratio had higher sensitivity (95%) and NPV (85%) than UAPI (Sensitivity 66.66%, NPV 79.40%) and MCA PI (Sensitivity 83.33%, NPV 77.27%), UAPI had higher specificity (93.10%) and PPV (87.5%) compared to cerebroplacental ratio (Specificity 87%, PPV 88%) and MCA PI (Specificity 85%, PPV 89.28%). Diagnostic accuracy of Cerebroplacental ratio (Accuracy=90%) was better than UAPI (Accuracy=82%) and MCA PI (Accuracy=84%) in predicting adverse outcomes.

Conclusion: In clinically diagnosed severe preeclampsia and suspected IUGR pregnancy, both Cerebroplacental ratio and Umbilical artery PI are strong predictors of adverse perinatal outcome. Cerebroplacental ratio is most sensitive and Umbilical artery PI is most specific index in predicting adverse outcome. Absent or reversed end diastolic flow in an umbilical artery is an ominous finding associated with major adverse perinatal outcome and mortality.

Keywords: High risk pregnancy; severe preeclampsia, IUGR and Triple vessel Doppler study; Perinatal outcome.

I. Introduction

Pre-eclampsia is one of the leading causes of maternal and fetal morbidity and mortality. It affects 2-5% of pregnancies and is principally a disease of first term pregnancy. Pre-eclampsia is a specific syndrome characterized by reduced organ perfusion secondary to vasospasm and endothelial pathophysiology. Almost all the morbidity being due to multisystemic manifestations in many organs including brain, liver, kidney and placenta. IUGR is a common complication of pre-eclampsia and is due to failure of normal placental invasion and development.

The primary pathology is the impairment of placental perfusion, which may be attributed to abnormal placentation of maternal vascular disease. Impaired placental perfusion is believed to result from insufficient invasion of maternal spiral arterioles by the trophoblast early in gestation. Consequently, the crucial hemodynamic changes seen in normal pregnant uterine vasculature – that is shift from low volume high resistance to high volume low resistance environment does not take place. This leads to increased

vascular resistance and decreased utero placental perfusion. The subsequent placental ischemia may lead to production of free radicals damaging the endothelial cells. As a result of impaired uteroplacental blood flow manifestations of pre-eclampsia may be seen in the fetoplacental unit. These include IUGR, oligohydramnios, placental abruption, fetal hypoxia, perinatal death and non-reassuring fetal status found on antepartum fetal surveillance by Doppler ultrasound.

The main goals of antepartum fetal surveillance are to identify fetuses at increased risk for perinatal mortality and morbidity. Doppler ultrasound allows a noninvasive assessment of fetal haemodynamics. Doppler investigation of the umbilical arteries provides information concerning perfusion of the fetoplacental circulation, while Doppler study of fetal vessels detects the haemodynamic rearrangements that occur in response to fetal hypoxia.

Umbilical artery (UA) Doppler velocimetry is the most rigorously evaluated test among the noninvasive tests of fetal wellbeing. Several authors have reported a low end diastolic velocity in the umbilical artery, a consequence of high flow resistance in capillaries of the terminal villi. A meta-analysis of randomized controlled trials of UA Doppler velocimetry in high risk pregnancies (mainly pregnancies with associated pregnancy induced hypertension and suspected IUGR) demonstrated that its use was associated with a trend towards reduction of perinatal mortality⁸. In response to prolonged fetal hypoxic stress, circulatory adaptation occurs, resulting in redistribution of the cardiac output to provide a constant oxygen supply to the brain and other essential organs (i.e., heart and adrenal glands). This compensatory adjustment, on which the brain sparing effect is based, associated with a rise in diastolic velocities in Doppler cerebral artery waveforms. This rise is considered a manifestation of cerebral vasodilatation, causing a decrease in Doppler indices such as the pulsatility index. At cordocentesis, a significant correlation has been observed between hypoxemia in fetuses with IUGR and abnormal middle cerebral artery (MCA) pulsatility index (PI).

Recent studies indicate that the cerebroplacental ratio of pulsatility index of MCA and UA is the most sensitive Doppler index for predicting perinatal outcome in fetuses with IUGR. In the majority of the severely growth retarded fetuses, sequential deterioration of arterial and venous Doppler precedes biophysical profile score deterioration. At least one third of fetuses show early signs of circulatory deregulation 1 week before biophysical profile deterioration, and in most cases, Doppler deterioration preceded biophysical profile deterioration by 1 day. This indicates the significance of Doppler study in these patients for early detection of fetal compromise.

Differences in study design, including the criteria for patient selection, the definition of adverse outcomes, different cut off levels between normal and abnormal test results makes direct comparison difficult. Our study was an effort at establishing the role of uterine artery; UA and MCA Doppler Ultrasound in predicting adverse perinatal outcome in the clinically suspected IUGR and preeclampsia pregnancies and to determine the role of Doppler velocimetry in clinical management of such pregnancies.

II. Objectives:

1. To analyze the blood flow in uterine artery, umbilical artery and middle cerebral artery using Doppler ultrasound in a group of patients with severe preeclampsia and severe preeclampsia with IUGR
2. To assess the value of Doppler ultrasound in analysing the perinatal outcome in patients with severe preeclampsia and severe preeclampsia and IUGR.
3. To evaluate the role of Doppler ultrasound in the management of patients with severe preeclampsia and severe preeclampsia and IUGR.

III. Materials And Methods

The study was conducted on fifty women with high risk pregnancies within inclusion criteria and fifty women with low risk pregnancies who were admitted to department of obstetrics and gynaecology at Meenakshi Medical college hospital and research institute, Kanchipuram from November 2010 to July 2012.

Study Subjects

Patients with inclusion criteria admitted/attending to department of obstetrics and gynaecology were assigned into two groups A and B. Each group included 50 cases. Group A included high risk pregnancies with inclusion criteria and group B included women with low risk pregnancies as control groups.

Inclusion Criteria

All antenatal cases more than 30 weeks of gestation clinically diagnosed as pregnancy induced hypertension with following inclusion criteria are included:

- Singleton pregnancies.
- Pregnant women with history and physical findings suggestive of
- Severe preeclampsia,

- IUGR (EFW < 10TH percentile for gestational age)
- Severe preeclampsia plus IUGR.
- Those who gave consent for the study.

Exclusion Criteria

The pregnancies with following conditions were excluded;

- Cardiovascular disease
- Multiple gestations
- Fetuses with congenital anomalies
- Renal disease
- Essential hypertension prior to pregnancy and other high risk pregnancies
- Intrauterine death at the time of first Doppler examination.

The gestational age was based on last menstrual period (LMP), ultrasound biometry performed before the 20th gestational week, when the LMP is uncertain or not known and early ultrasound before 13 weeks has not been performed. Follow up Doppler studies were performed if clinically indicated to determine a favourable or a worsening trend in the Doppler indices. However, only the results of the first Doppler ultrasound were used for analysis of perinatal outcome.

Procedure:

The patient was explained about the non-invasive/ atraumatic nature of the procedure. Synthetic ultrasound gel was applied liberally over the abdomen to get a good acoustic coupling. The instrument used was VOLUSON S6 PRO Colour Doppler ultrasound machine with a convex transducer of 2-5 MHz frequency. Doppler wave form was obtained after localizing the vessels by B mode real time scanner. Pulsed Doppler was used to get the Doppler signals after localizing the vessels. The maximum Doppler shift frequencies were obtained and various ratios were calculated from each vessel. Doppler examination was done when foetus was in apneic state to avoid the influence of fetal respiration on Doppler signals.

Identification of various arteries and their criteria

1. Uterine Artery: Colour Doppler facilitates identification of the uterine artery substantially. The uterine signal was obtained per abdomen by pointing the probe in the iliac fossa towards the lower para-cervical area. In the colour mode, the uterine artery is seen to cross the external iliac artery, just after its origin from the internal iliac artery and this point was taken as the sampling point. Doppler wave forms were obtained. Values of S/D ratio, RI and PI >95th percentile as per the Harrington et al Doppler indices and persistent early diastolic notch is considered abnormal.

2. Umbilical Artery: Flow velocity waveforms from umbilical artery can be easily obtained, for this colour flow is not usually needed. Doppler signals can be acquired from different points in cord, usually from mid portion of cord. Values of S/D ratio, RI and PI >95th percentile as per the Harrington et al Doppler indices, presence of absent end diastolic velocity (AEDV) and reversed end diastolic velocity (REDV) were considered abnormal.

3. Middle Cerebral Artery (MCA): MCA was visualized in transverse axial view of fetal head at a slightly more caudal plane than the one used for BPD. PI and RI < 5TH percentile as per the Harrington et al Doppler indices were considered abnormal.

Outcome criteria:

Doppler US results were analysed for prediction of perinatal outcome. Outcome variables included are:
Birth Weight (less than 10th percentile)

- Perinatal death
- Emergency CS for fetal distress
- Low APGAR score (5 min APGAR score less than 7)
- Admission to NICU for complications of Low Birth Weight.

Pregnancy was considered to have "Adverse outcome" when any of the following complications were present

- Perinatal death
- Emergency CS for fetal distress
- 5 minute Apgar score of less than 7
- Admission to NICU for complications of low birth weight.

Pregnancy outcome was considered to be Uneventful or Favourable when the above complications were absent. The outcome for each pregnancy was obtained by examining the labor ward records and neonatal intensive care unit records wherever appropriate. The UA Pulsatility index ratios were considered abnormal if

the value was above the 95th percentile of previously published values for gestational age. The MCA pulsatility index was considered abnormal if the value was below the 5th percentile of previously published values for gestational age. The MCA/UA PI ratio (cerebroplacental ratio) is considered abnormal when it is less than 1.08 as given by the Gramellini D et al.

IV. Results

In the present study out of fifty cases of study groups, 34 showed positive Doppler indices in any or combinations of the three vessels studied. The remaining 16 cases showed normal Doppler indices in all the three vessels studied.

V. Discussion

Preeclampsia and Intrauterine growth restriction is associated with increased risk of perinatal morbidity, mortality and impaired neurological development. It is a challenge to differentiate the foetus with pathologic growth restriction and hence at risk for perinatal complications from constitutionally small but healthy foetus. Doppler velocimetry is a non-invasive technique that evaluates abnormal fetal haemodynamic that takes place in response to changes in placental resistance. A Doppler index that reflects both of these areas can be useful for identifying fetuses with increased placental and decreased cerebral resistance.

Umbilical artery and middle cerebral artery Doppler ultrasound clearly depicts the information about placental resistance and the changes in the fetal haemodynamic in response to it. Umbilical arteries Doppler reflects the maldevelopment of the placental tertiary stem villi which increases the placental resistance leading to growth retarded foetus. Middle cerebral artery Doppler has enabled the confirmation of brain sparing effect in IUGR. Hence we chose the UA PI, MCA PI and MCA PI/UA PI i.e. cerebroplacental ratio as the tool for predicting the perinatal outcome in IUGR.

We studied the Doppler index of umbilical artery only after 30th week, because in agreement with Schulman, Gramellini, we believe that it is difficult to define normal or abnormal umbilical flow velocity before 30th week, with the exception of absent end diastolic flow velocity after 20th week.

We studied the Doppler index of middle cerebral artery because it is the most accessible artery to see the cerebral redistribution as it is the main branch of the circle of Willis and carries 80% of the blood flow to the ipsilateral cerebral hemisphere, a constant 3%–7% of cardiac output throughout gestation.

The MCA PI and UA PI values for the corresponding gestational age were compared with reference values given by Harrington et al 27 normograms. MCA PI was considered abnormal when it is less than 5th percentile for that gestational age and UA PI was considered abnormal when it is more than 95th percentile for the corresponding gestational age. It is possible to use a single cut off value for cerebroplacental ratio after 30th week because cerebral-umbilical Doppler ratio does not vary significantly between 30th and 40th weeks as reported by Waldimiroff et al 12 who observed a significant difference in cerebroplacental ratio only between weeks 26-38. After 26th week, the statistical comparison showed no significant differences between the intervals considered. Arbeille 11 et al also found the cerebral-placental ratio constant during the pregnancy and suggested 1 as the cut off value and all values below 1 were considered abnormal. We considered the study of Gramellini et al 13 that cerebroplacental ratio less than 1.08 as abnormal.

We have studied about 50 pregnancies with preeclampsia and clinical suspicion of IUGR. 70% of neonates (n=35) had birth weight of less than 2.5 kg. Of the 50 neonates, 19 neonates were admitted to NICU, 8 neonates had 5 min Apgar score of less than 7 and 15 babies were born by emergency caesarean section for fetal distress. There were 8 neonatal deaths. Of the 8 neonatal deaths, 1 case had reversal of diastolic flow and 5 had absent diastolic flow.

Normal and abnormal Doppler wise distribution of cases in Present study group and reference studies

	Normal	Abnormal
Bhatt CJ et al	44%	56%
U. Gupta et al	45%	55%
Present Study	32%	68%

As compared with other studies present study also had majority of cases with abnormal Doppler **Umbilical artery** - It was found to have low sensitivity of 66.6% when compared to MAC PI and cerebroplacental ratio. The sensitivity was comparable with that of Fong KW et al and Gramellini et al.

	Fong K W et al	Gramellini et al	Present study
Sensitivity	44.7%	64%	66.6%
Specificity	86.6%	90.7%	93.1%
PPV	54%	72.7%	87.5%
NPV	81.7%	86.7%	79.4%

The specificity of the UA PI 93.1% was found to be better than other variables. The specificity was comparable with the above mentioned studies. The UA PI is effective to rule in the possibility of adverse perinatal outcome when it is abnormal. The Positive Predictive Value of UA PI 87.5% was more than that of MCA PI and Cerebroplacental ratio. It indicated the likelihood of adverse perinatal outcome in growth retarded fetus with abnormal UA PI. The positive predictive value was higher when compared to all other studies. The negative predictive value 79.4% obtained in our study was comparable with the above mentioned studies. This was less than that of MCA PI and cerebroplacental ratio.

Our findings confirm the results of Fong KW et al, Chan et al and Gramellini et al that abnormal UAPI is associated with adverse outcome like NICU admission for low birth weight and low Apgar scores than the one with normal UA PI. It provides the most useful information for differentiating fetuses already compromised or likely to become compromised from those that are non-compromised. Our findings agree with Harrington et al that umbilical artery can be normal in term and near term with abnormal middle cerebral artery.

Middle cerebral artery - was found to have a sensitivity of 83.3% less than that of cerebroplacental ratio and more than that of UA PI. The values were not comparable with the below mentioned studies.

	Fong K W et al	Gramellini et al	Present study
Sensitivity	72.4%	24%	83.3%
Specificity	58.1%	100%	85%
PPV	37.7%	100%	89.28%
NPV	85.7%	77.30%	77.27%

It showed specificity 85%. It agrees with Fong et al that MCA PI is less specific than cerebroplacental ratio and UA PI. The study had more number of false positive values. There are several possible explanations for the low Specificity of the MCA pulsatility index for adverse perinatal outcome. Among several published normograms for MCA PI.

the cutoff values for an abnormal MCA pulsatility index are similar up to about 30 weeks gestational age but differ after 32 weeks. The normograms we chose to use for analysis are from the largest published cross-sectional study by Harrington K et al.

Positive predictive value of MCA PI 89.28% in predicting adverse perinatal outcome is more than that for other variables, which can be attributed to the less false positive values. The negative predictive value of 77.27% is comparable with that of Gramellini et al study. It is more useful in ruling out the possibility of adverse perinatal outcome.

Cerebroplacental ratio - It had the highest sensitivity value of 95.6% more than any other variable. The values were not comparable with any other study because of variation in the prevalence of IUGR.

The highest sensitivity of cerebroplacental ratio indicates its usefulness of cerebroplacental ratio in ruling out the possibility of adverse perinatal outcome in IUGR when the ratio is normal for the gestational age. It showed the specificity of 87% which is less compared to UA PI and better than the MCA PI. The values were comparable with Fong et al study.

	Fong K W et al	Gramellini et al	Present study
Sensitivity	51.3%	68%	95%
Specificity	80.6%	98.4%	83%
PPV	48.1%	94.4%	88%
NPV	82.5%	88.8%	85%

Cases with Doppler abnormality in Present study group and reference studies

	Abnormal Ut.A. S/D	Abnormal UA S/D
Trudinger et al	47.33%	40%
U. Gupta et al	55%	39%
Saxena et al	77%	40%
Khalid et al	94.44%	80.56%
Present Study	82.30%	81.70%

Present study has shown majority of cases (85.71%) with abnormal umbilical artery S/D ratio, which is comparable to the study conducted by Khalid et al. In other studies majority showed abnormal uterine artery S/D ratio.

In the present study, majority of the cases (63%) with abnormal Doppler indices had NICU stay whereas Cutis L Lowery Jr study showed 86 % of NICU admissions with abnormal Doppler indices

Distribution

	% of Abnormal Doppler with IUGR
Fleischer et al	67%
Bhatt CJ et al	60%
Khalid et al	30.56%
Present study	37.14%

Of IUGR In Abnormal Doppler Indices

Fleischer et al and Bhatt CJ et al showed 67% and 60% of IUGR in abnormal Doppler indices whereas in the present study it was 37.14% and in the study done by Khalid et al 59 it was 30.56%.

AEDV And REDF - Perinatal Mortality

Bhatt CJ et al	50%
Battaglia et al	50%
Present Study	100%

100% mortality was seen in cases with reversed diastolic flow and absent diastolic flow. This confirms the findings of Karsdropetal, which showed that absent and reversed diastolic flow is better indicator of the adverse perinatal outcome.

The current study has shown that absent or reversed end – diastolic flow in the umbilical artery is strongly associated with major perinatal morbidity with mortality. This has been well recognized in the literature that there is strict correlation between the abnormal UA PI and poor perinatal outcome in IUGR. Studies have shown that absent and reversed diastolic flow in the umbilical artery is associated with increased perinatal mortality and morbidity.

Our results in evaluating the usefulness of umbilical artery and middle cerebral artery Doppler in predicting the adverse perinatal outcome in preeclampsia and IUGR indicate that both abnormal umbilical Doppler indices and cerebral-umbilical ratio are strong predictors of adverse outcome in IUGR. The MCA PI alone is not a reliable indicator when used alone. The combination of umbilical and fetal cerebral Doppler indices may increase the utility of Doppler ultrasound in clinically suspected IUGR.

Summary

Fifty (50) patients diagnosed to have severe preeclampsia, preeclampsia with IUGR with gestational age between 31-40 weeks were studied and subjected to colour Doppler ultrasonography. Uterine, umbilical and fetal middle cerebral arteries were studied. S/D ratio of >2.6, RI>0.58, persistent early diastolic notch in uterine artery; S/D ratio of >3, RI >0.7, AEDV and REDV in umbilical artery; RI<0.7, PI<1.3 in middle cerebral artery were considered abnormal. The results were correlated with parameters of perinatal outcome.

- □ In our study, age group 20-24 years was the common group. The mean maternal age was 23.1 years.
 - □ Out of 50 cases studied, 34 (68%) showed positive Doppler indices in any of the three vessels studied. The remaining 16(32%) cases showed normal Doppler indices in all the three vessels studied.
 - □ Among abnormal 34 cases, 29(85 %) cases, 25(74%) cases and 15 (44%) had abnormal Middle cerebral artery, uterine artery and umbilical artery Doppler indices respectively.
 - □ Maximum number of abnormal cases (95.%) were induced and delivered.
 - □ Babies of 19 cases (55%) with abnormal Doppler indices had NICU stay whereas 4 babies (8 %) of the cases with normal Doppler indices had NICU stay.
 - □ Among abnormal cases, 8 babies (24%) had APGAR score <7 compared to 1 baby(3%) in normal cases (p<0.001).
 - □ 36% of normal cases and 45.5% of abnormal cases had babies with birth weight in the range of 1.5 to 1.99 Kg. 5 babies (14%) of abnormal cases had <1 kg birth weight and none of the babies of normal cases had <1 kg birth weight.
- Comparison of mean birth weight between Normal (1.94±0.40 Kg) and Abnormal(1.49±0.39) was highly significant [t = 4.56, p<0.001]
- □ Number of babies with SGA in abnormal Doppler indices group were 13(37.14%) when compared to 4 (16%) in normal Doppler indices group (χ²= 5.63, p< 0.05).

- □ Babies of 21 cases (60%) with abnormal Doppler indices had neonatal complications where as only 7 babies (28%) had neonatal complications in normal Doppler indices group ($p < 0.001$).
- □ There were 8 perinatal deaths in abnormal Doppler indices, out of which 4 were still born and another 4 were neonatal deaths.
- □ In 5 patients with AEDV there were 2 still born, 3 neonatal deaths and 1 case with REDF had early neonatal death accounting for 100 % Perinatal mortality in both AEDV REDF.

VI. Conclusion

- □ Pre eclampsia is associated with significant fetal morbidity and mortality.
- □ There is progressive fall of vascular resistance in uterine, placental and umbilical arteries as gestational age increases. This will result in high end diastolic blood flow in all these blood vessels.
- □ Abnormal uterine, umbilical artery and middle cerebral artery Doppler flow velocimetry studies associated with severe form of hypertension and higher incidence of IUGR.
- □ Absent end diastolic flow and Reverse diastolic flow in umbilical artery indicates severe fetal distress and is associated with 100% perinatal mortality.
- □ Abnormal PI of MCA/ umbilical artery ratio is also associated with IUGR.
- □ CPR is more sensitive than MCA and umbilical artery.
- □ Because the changes in the uterine and umbilical circulation strongly correlate with the perinatal outcome, Doppler velocimetry is a primary tool for fetomaternal surveillance in hypertensive pregnancy.
- □ It is safe, non-invasive technique, easy to perform, easy to interpret, and hence most valuable tool in the management of high risk pregnancy.
- □ There was high incidence of LSCS due to fetal distress, low birth weight, increased incidence of NICU admission and low Apgar score at 1 and 5 minutes with abnormal Doppler indices in the study group.
- □ **Thus triple vessel Doppler study is very useful in predicting high risk pregnancies with adverse perinatal outcome when the Doppler velocimetry is abnormal**

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X. Tables

Table-1: Age Distribution of Cases

Age (Years)	Study Group	Control Group
<20	3	6
20-24	34	36
25-29	11	5
>30	2	3

Table -2: Gestational Age Distribution in study group and control group

Gestational age (Wk)	Study Group	Control Group
31-32	9	0
33-34	5	1
35-36	10	3
37-38	19	37
39-40	7	9

Table -3: Distribution Characteristics of Placental Maturity

Placental Grading	Study Group	Control Group
2	34	43
3	16	7
Total	50	50

Table -4: Amniotic Fluid distribution in the study group

Amniotic Fluid	Doppler Normal	Doppler Abnormal	Total
Oligo	2	13	15
Normal	17	18	35
Total	19	31	50

Table -5: Maternal complications of study group

Maternal Complications	Number Of Cases	Percentage
Iugr	22	44
Anaemia	8	16
Previous Lscs	2	4
Help Syndrome	3	6

Table -6: Pregnancy Outcome in the study group

Pregnancy outcome	No. of cases		Percentage	
	Study group	Control group	Study group	Controlgroup
Adverse	42	10	84	20
Uneventful	8	40	16	80
Total	50	50	100	100

Table -7: Adverse outcome Parameters in Study and Control Groups

Pregnancy outcome	No. of cases		Percentage	
	Study group	Control group	Study group	Control group
EmLSCS	15	9	30	18
Low Apgar Score	8	0	16	0
NICU Admission	19	0	38	0
Neonatal Death	8	0	16	0
Low Birth Weight	35	7	70	14
Preterm Delivery	24	3	48	6

70% of neonates (n=35) had birth weight of less than 2.5 kg. Of the 50 neonates, 19neonates were admitted to NICU, 8 neonates had 5 min Apgar score of less than 7 and 15babies were born by emergency caesarian section for fetal distress.

Table-8: Normal and Abnormal Doppler Wise Distribution of Cases

Doppler	Number	Percentage
Normal	16	32
Abnormal	34	68
Total	50	100

Table -9: Doppler velocimetry of umbilical artery and perinatal outcome

	Complications or death		Live or healthy		Total	
Abnormal	14	93.3%	1	6.7%	15	100
Normal	8	22.85%	27	77.14%	35	100
Total	22	44%	28	56%	50	100

$\chi^2 = 31.04$

DF=1

P<0.001

There is significant association between Doppler study result of umbilical artery and perinatal outcome

Table -10: Doppler velocimetry of middle cerebral artery and perinatal outcome

	Complications or death		Live or healthy		Total	
Abnormal	21	72.41%	8	27.5%	29	100
Normal	7	33.3%	14	66.7%	21	100
Total	28	56%	22	44%	50	100

$\chi^2 = 17.39$

DF=1

P<0.001

There is significant association between Doppler study result of middle cerebral artery and perinatal outcome

Table -11: Diastolic notch of uterine artery and perinatal outcome.

No. of cases	Adverse outcome		Live & Healthy	
20	11	55%	9	45%

Table-12: Cerebro-placental ratio (MCA PI/UA PI) in prediction of IUGR

Parameters	No. of IUGR Cases	Percentage
CPR<1	16	72.73
CPR>1	6	27.27
Total	22	100

Table -13: Spectral characteristics of umbilical artery and perinatal outcome.

	No. of cases	Mortality	Percentage
AEDF	05	05	100
REDF	01	01	100

Table-14: Performance Characteristics of Doppler Indices

Parameters	Sensitivity	Specificity	PPV	NPV	Diagnostic Accuracy
UA PI	66.66	93.10	87.50	79.40	82
MCA PI	83.33	85	89.28	77.27	84
CPR	95	87	88	85	90

X. Legends

Figure-1: Normal uterine artery wave form Figure-2: Normal Umbilical Artery wave
 Figure-3: Normal MCA wave form Figure-4: Umbilical artery with decreased diastolic flow
 Figure-5 :Umbilical artery with AEDF Figure-6 :Umbilical artery with REDF
 Figure-7: Uterine Artery with Notch Figure 8: MCA with Decreased PI

Figure-1: Normal uterine artery wave form

Figure-2: Normal Umbilical Artery wave

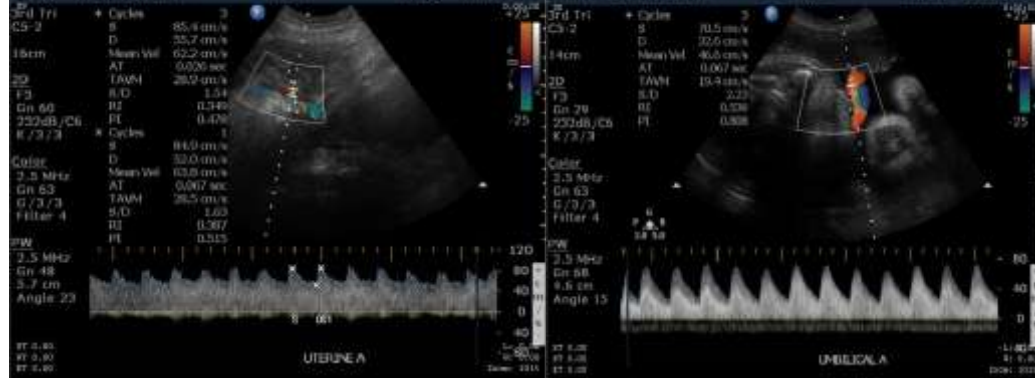


Figure-3: Normal MCA wave form

Figure-4: Umbilical artery with decreased diastolic flow



Figure-5: Umbilical artery with AEDF

Figure-6 :Umbilical artery with REDF

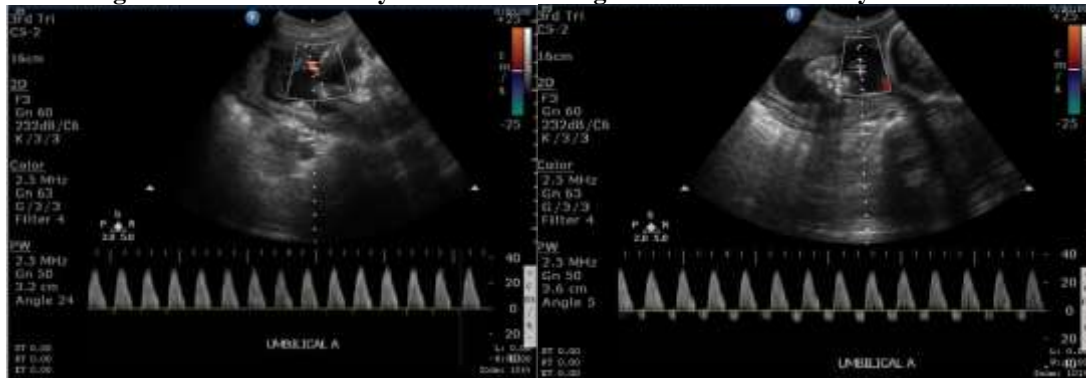


Figure-7: Uterine Artery with Notch

Figure 8: MCA with Decreased PI

