Research Article

Best color Doppler indices in prediction of fetal hypoxia in IUGR fetuses

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Abstract

Objective: To determine the best predictor of fetal hypoxia amongst the color Doppler indices resistivity index(RI), pulsality index(PI) and systolic/ diastolic (S/D) ration of umbilical artery (UA), middle cerebral artery(MCA), descending abdominal aorta (DAA), MCA/UA PI ratio and abnormal flow pattern, absent end diastolic flow/reverse end diastolic flow (AEDF/REDF) in umbilical artery and descending abdominal aorta, in prediction of adverse perinatal outcome in normal and intrauterine growth retardation (IUGR) fetuses with or without pregnancy induced hypertension (PIH). **Material and Method**: 100 women with normal Singleton pregnancies and 100 women with IUGR with or without PIH or both were prospectively examined with Doppler Ultrasonography of the umbilical artery, middle cerebral artery & descending abdominal aorta and perinatal outcomes was evaluated in relation to their indices and compared with each other. **Observation:** In study group sixty four fetuses (64%) had one major or minor adverse perinatal outcome in comparison to control group which had only 6% adverse perinatal outcome. In study group premature delivery was 46%, lower segment cesarean section (LSCS) was 38%, and perinatal death was 22%. Fetuses with absent end diastolic flow/reverse end diastolic flow (AEDF/REDF) in umbilical artery and descending abdominal aorta had 100% perinatal mortality. **Conclusion**: Umbilical artery SD Ratio (cut off ≥3), middle cerebral artery / umbilical artery PI < 1.08, AEDF / REDF abnormal flow pattern in umbilical artery and descending abdominal aorta were found to be the best Doppler indices for prediction of adverse perinatal outcome in women with PIH and IUGR.

Keywords: Color Doppler indices, Intrauterine Growth Restriction, Middle Cerebral Artery, Perinatal Outcome, Umbilical Artery.

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Introduction

Establishment of a good utero-placental circulation is necessary for normal pregnancy [1]. Initially when the placenta is small and utero-placental circulation is not developed, there is high resistance flow in umbilical artery, as pregnancy advances utero-placental circulation is well established S/D ratio of umbilical artery decreases [2]. Failure in establishment of a good utero-placental circulation due to any region fetal development become restricted and leads to intrauterine growth retardation (IUGR). IUGR is associated with an increased risk of perinatal mortality, morbidity, and impaired neurodevelopment [1]. PIH (preeclampsia) is the commonest cause of utero-placental insufficiency. Delivery is the only cure for preeclampsia for the mother but it may not be optimal for premature fetus before 34 weeks of gestation. To avoid inappropriate early intervention it is necessary to make an accurate assessment of fetal well being. The role of color Doppler is to detect these abnormal vascular resistance patterns and thus to detect the compromised fetus [3]. Here we try to find out the best predictor amongst the color Doppler indices to predict the fetal hypoxia and thus adverse fetal outcome in IUGR and normal fetuses.

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Material and Methods

This is a Prospective comparative study conducted between August 2008 to August 2009, in the Department Of Radiodiagnosis and Imaging in Pt. J.N.M. medical College and associated Dr BRAM Hospital, Raipur, CG.

The population comprised of 200 pregnancies. Out of 200 women, 100 women showing normal fetal growth parameters & normal maternal blood pressure were included in the control group and 100 women showing abdominal circumference less than 10^{th} percentile for their gestational age or pre-eclamptic mother were included in the study group.

Gestational age determination was based on a best estimate from menstrual history, clinical gestational age. Pregnancy with unknown LMP, Pregnancies with multiple gestations and congenital anomalies were excluded from the study.

The ultrasound machine used was Aloka Prosound (MODEL –SSD4000) Color Doppler machine with a transduser frequency was 3.5MHz. The Doppler waveform and PI, RI and S/D ration indices of Umbilical Artery (UA), Middle Cerebral Artery (MCA), Descending Abdominal Aorta (DAA) were studied with the mother in supine position during fetal inactivity and apnea. All vessels were examined in the standard plane.

We followed the reference value of different authors for the abnormal indices. Doppler indices were considered abnormal when- (1).Umbilical artery pulsatility index more than 95 percentile [4]. (2).Umbilical artery S/D ratio more than 3 or more than 95 percentile [5]. (3) Middle cerebral artery pulsatility index less than 5 percentile [6]. (4). Descending abdominal aorta pulsatility index greater than 95 percentile [4].

The ratio examined were considered abnormal when- (1) MCA/UA PI ratio less than 1.08 or less than 2SD [4]. (2) MCA/UA S/D ratio less than 1[7]. Fetal outcome was divided into major and minor adverse outcome. The major outcome included the stillbirths, early neonatal death, prolonged NICU admission (>7days), hypoxic ischemic encephalopathy (HIE), intracranial hemorrhage (ICH), necrotizing enterocolitis (NEC), and congestive cardiac failure (CCF). The minor outcome included LSCS for fetal hypoxia, preterm delivery (<37 weeks) and Apgar score at 5 min <7 [8].

The patients were followed by serial Doppler assessment and the result of the last Doppler examination within 14 days of delivery was considered in the subsequent correlation with perinatal outcomes. All the indices and ratios of the study and control group were analyzed and compared with validity of test and chi test.

Result

In study group sixty four fetuses (64%) had adverse perinatal outcome in comparison to control group which had only 6% adverse perinatal outcome.

Table No1: Adverse perinatal outcomes

Adverse Perinatal outcome indicator*		Study No.	Control No.	Total No.	χ^2 value	P value	Si
Major							
1	Stillbirth	12	0	12	6.383	0.012	S
2	Neonatal death	10	0	10	5.263	0.022	S
3	NICU admission >7 days	18	2	20	3.840	0.05	S
4	HIE	4	0	4	2.041	0.153	NS
5	ICH	4	0	4	2.041	0.153	NS
6	NEC	2	0	2	1.010	0.315	NS
7	CCF	2	0	2	1.010	0.315	NS
Minor							
8	LSCS for fetal distress	32	2	34	15.946	0.000	HS
9	Premature birth	46	4	50	23.520	0.000	HS
10	5-min Apgar score <7	20	2	22	8.274	0.004	HS

* - One newborn can have more than one adverse outcome
Si= Significance; S= Significant; NS= Not Significant; HS= Highly Significant
HIE= Hypoxic Ischemic Encephalopathy; ICH= Intracranial Hemorrhage;
NEC= Necrotizing Enterocolitis; CCF= Congestive Cardiac Failure

We found major adverse outcome as still birth 12, neonatal death 10 and NICU admission for >7days 18 in study group while no still birth, no neonatal death and 2 NICU admission for >7 days in control group with p value –0.012, 0.022 and 0.05 with statistically significant result. Other major perinatal outcome were HIE (Hypoxic ischemic encephalopathy), Intracranial Hemorrhage (ICH), Necrotising necrocolitis (NEC) and Congestive cardiac failure (CCF) with numbers 4, 4, 2 and 2 respectively. P values of all were more then 0.05 and were statistically insignificant. We found minor adverse outcome as LSCS for fetal distress, Premature birth and 5-min APGAR score <7 with numbers -32, 46, 20 in study group and numbers -2, 4, 2 in control group respectively with p value -0.00 in first two and 0.004 in last one. They were statistically highly significant. [Table-1].

Table No 2: Adverse [major + minor] perinatal outcome of study population according to doppler indices : performance characteristics

Criterion	Sensitivity	Specificity	Predictive value		Accuracy
			+ve	-ve	
UA PI ≥ 95 percentile	80	70.77	59.57	86.79	74
UA S/D ≥ 3	86.96	71.21	51.28	94	75.28
UA S/D ≥ 95percentile	69.57	78.78	53.33	88.14	76.40
MCA PI < 5 percentile	47.06	81.81	57.14	75	70
DAA PI≥95 percentile	44.4	59	64	56.5	72.50
MCA/UA PI < [mean - 2SD]	77.14	83.08	71.05	87.10	81
MCA/UA PI < 1.08	73.53	89.40	78.12	86.76	84
MCA/UA [S/D] <1	47.83	84.84	52.38	82.35	75.28
AEDF/REDF UA	34.37	100	100	76.40	79
AEDF/REDF DAA	33.47	100	100	76.30	78

In prediction of adverse perinatal outcome in IUGR fetuses umbilical artery S/D ratio ≥ 3 had highest sensitivity (86.96%) followed by umbilical artery PI ≥ 95 percentile (80%). While the specificity and positive predictive value in prediction of adverse perinatal outcome in IUGR fetuses was highest in AEDF/REDF in UA and DAA (100% each) followed by MCA/UA PI ratio <1.08 with sensitivity of 89.40% and positive predictive value of 78.12%. Highest negative predictive value was fond in UA S/D >3 with (94%). Highest accurate Doppler indices in prediction of adverse perinatal outcome in IUGR fetuses was MCA/UA PI ratio with <1.8 with (84%) [Table-2].

Table No 3: Adverse [only major] perinatal outcome of study population according to Doppler indices: performance characteristics

Criterion	Sensitivity	Specificity	Predictive value		Accuracy
			+ve	-ve	
UA PI ≥ 95 percentile	94.74	62.96	37.5	98.08	69
UA S/D ≥ 3	100	61.73	20.51	100	65.17
UA S/D ≥ 95percentile	87.5	71.6	23.33	98.30	73.03
MCA PI < 5 percentile	63.16	81.48	41.38	90.14	76
DAA PI≥95 percentile	41.6	56	21.76	91.7	53.4
MCA/UA PI < [mean - 2SD]	89.47	75.31	45.94	96.83	78
MCA/UA PI <1.08	89.47	81.48	53.13	97.06	83
MCA/UA [S/D]<1	75	81.48	28.57	97.06	80.90
AEDF/REDF UA	57.89	100	100	90	92
AEDF/REDF DAA	56.66	100	100	89	90

In prediction of only major adverse outcome umbilical artery S/D ratio with cut off value of 3 had highest sensitivity (100%) and negative predictive value (100%) while AEDF/REDF in UA and DAA had highest specificity(100%), Positive predictive value(100%) and accuracy (92%) followed by MCA/UA PI ratio with cut off value of 1.08 (83%)[Table 3].

In our study Mean 'diagnosis to delivery' interval in control group was 2.72 weeks while in study group it was 1.24 weeks. Mean birth weights in study and control groups were 2781 ± 197 gm and 1621 ± 321 gm respectively.

Discussion

In normal pregnancy, the indices; S/D and Pl decrease with advancing gestation in descending fetal aorta & Umbilical artery (fig-1), But in IUGR first there is decreased diastolic flow in the umbilical artery due to increase in the resistance that occurs in small arteries and arterioles of the tertiary villi [9][10][11]. This raises the S/D ratio and Pl of umbilical artery. As the placental insufficiency worsen, the diastolic flow decreases, then become absent (fig-2), and later reverse(fig-3) flow pattern noted on descending fetal aorta & umbilical artery [12][13].

Fig 1: Umbilical artery normal velocimetry

Fig 2: Absent diastolic flow in Umbilical artery

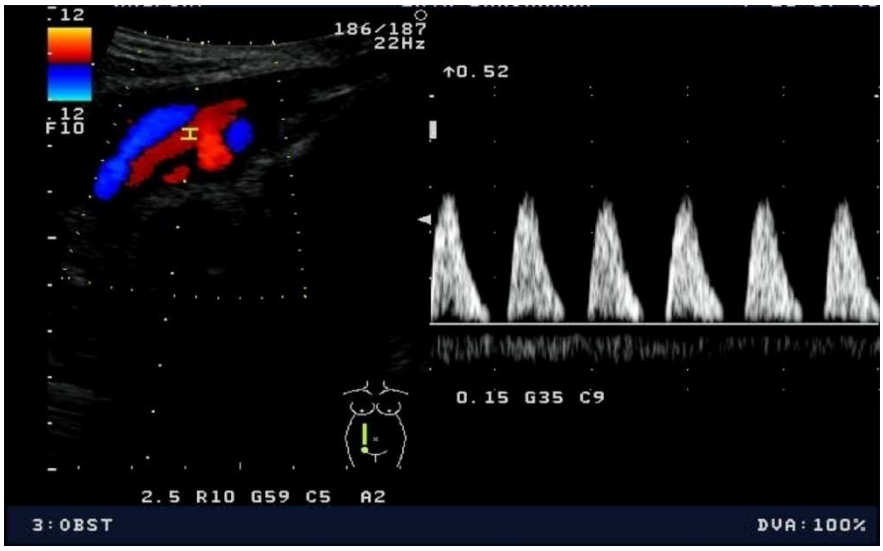


Fig 3: Reversed diastolic flow in Umbilical artery

Fetal MCA is a low resistance circulation throughout pregnancy [14][15] and accounts for 7% of fetal cardiac output (fig-4). In fetal hypoxia and ischemia increase in diastolic flow with decreased pulsatility index shows the brain sparing taking place in compromised fetuses [3] (fig-5)

Fig.- 4: Middle cerebral artery normal velocimetry

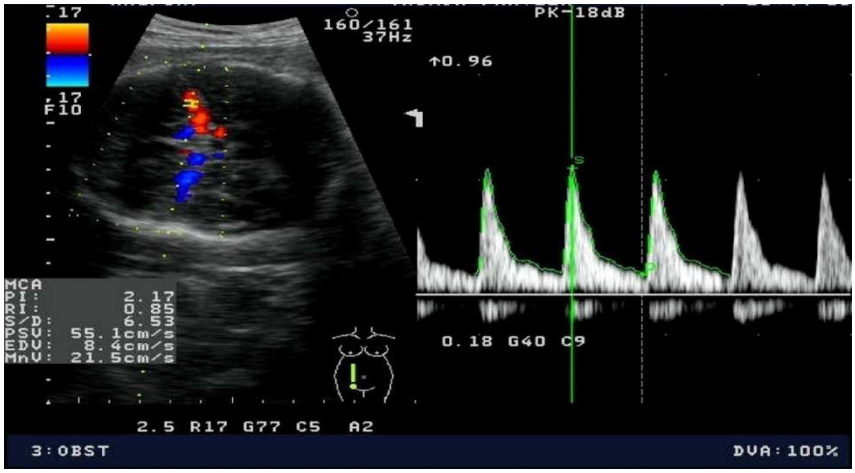
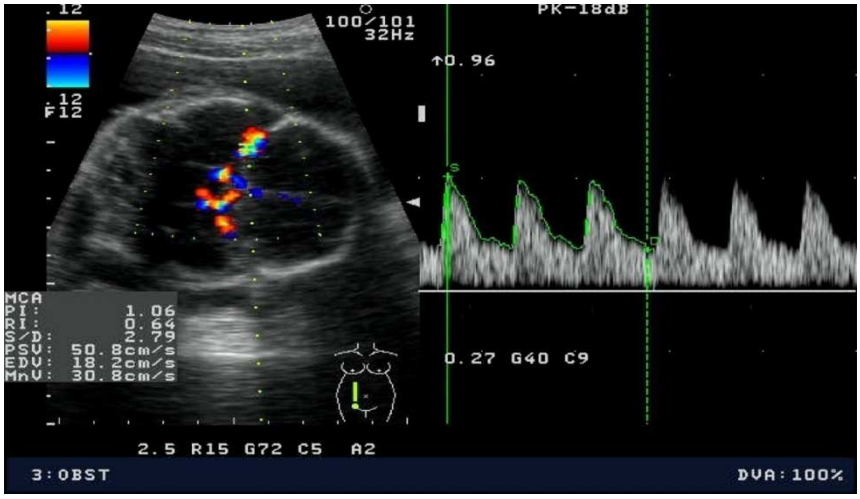


Fig.-5: Increased diastolic flow in Middle Cerebral artery



Fetal hypoxia results in to adverse fetal outcome. Adverse fetal outcome is divided in to two groups major and minor adverse fetal outcome on the basis of severity [11].

We studied the diagnostic and prognostic value of different color doppler indices in term of sensitivity, specificity, Positive predictive value, negative predictive value and accuracy in prediction of adverse fetal outcome.

We found UA S/D ratio ≥ 3 and PI ≥ 95 percentile as most sensitive and carry highest negative predictive value. This result is comparable with the study result of Lakhkar BN et al [3], Fong KW et al [8] and Strigini FAL et al [14] [Table-4].

Table No 4: Performance characteristic of Umbilical artery, fetal aorta and middle cerebral artery in prediction of adverse perinatal outcome.

Parameter assessed		Author	Se	Sp	PPV	NPV
UAPI	>2SD	Fong [8]	44.7	86.6	54	86.7
	>2SD	Lakhkar[3]	50	59	66.6	81.7
	>95percentile	Present study	80	70.77	59.57	41.9
UAS/D	>2SD	Strigini[14]	53	94	40	96
	>2SD	Lakhkar[3]	66.6	45.4	66.6	45.4
	>3	Present study	86.96	71.21	51.28	94
	>95percentile	Present study	69.57	78.78	53.33	88.14
MCA PI	<1.5SD	Strigini[14]	40	95	36	95
	<2SD	Fong[8]	72.4	58.1	37.7	85.7
	<2SD	Lakhkar[3]	41.6	90.9	88.2	48.7
	<5percentile	Present study	47.06	1.81	57.14	75
DAA PI >2SD Lakhkar 44.4 59 64 56.5						

MCA /UA PI Ratio <1.8 was found to be highly specific and most accurate. This result is comparable with the study result of Lakhkar BN et al [3], Fong KW et al [8],Bahado Singh RO et al [15] and Odibo AO et al [16] [Table-5].

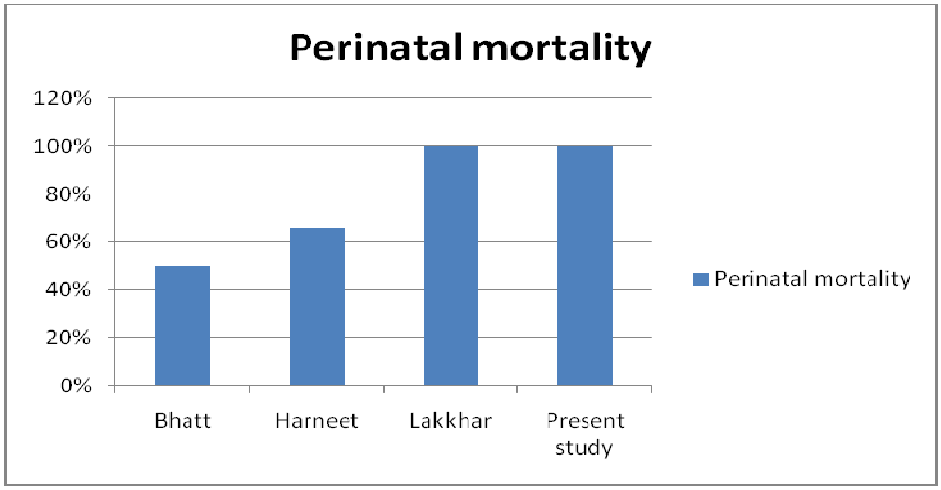
Table No 5: Performance characteristic of MCA/UA(PI,S/D) ratio in prediction of adverse perinatal outcome

Parameter assessed		Author	Se	Sp	PPV	NPV
PI	<2SD	Bahado Singh[15]	63	90	81	77
	<5percentile	Odibo[16]	65	73	73	65
	<1.08	Odibo[16]	72	62	68	67
	<2SD	Fong[8]	51.3	80.6	48.1	82.5
	<1	Lakhkar[3]	47.2	86.3	85	50
	<1.08	Present study	73.53	89.4	78.12	86.76
	<2SD	Present study	77.14	83.08	71.05	87.1
S/D	<1	Lakhkar[3]	55.5	72.7	76.9	50
	<1	Present study	47.83	84.84	52.38	82.35

Absent end diastolic flow (AEDF) or reversed end diastolic flow (REDF) in umbilical artery and DAA was most specific (100%) and highest positive predictive value (100%).

Absent end diastolic flow (AEDF) or reversed end diastolic flow (REDF) in umbilical artery and DAA was associated with 100 % mortality in our study group. Same result was also found in study of Lakhkar BN et al [3], Narula Harneet et al [17] and Bhatt CJ et al [18] (fig-6).

Fig. 6: Perinatal mortality in subject having absent or reversed end diastolic flow in descending fetal aorta and umbilical artery.



Conclusion

The prevalence of low birth weight in India is approximately 26% and out of this the proportion of low birth weight due to IUGR is approximately 54.2%. [19], to do find out how-much the IUGR & PIH has affected the fetus and to timely intervene, various Doppler indices have been – proposed by various authors. For the prediction of adverse perinatal outcome in women with PIH & IUGR, the best Doppler indices, according to our study are UA SD Ratio (cut off ≥3), MCA / UA PI < 1.08 and AEDF / REDF abnormal flow pattern in UA and DAA which should always be mentioned on the USG with color Doppler report of patients with PIH & IUGR. A timely Doppler study of pregnancy for these indices will help to reduce the perinatal morbidity & mortality in PIH and IUGR fetuses.

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Permission of IRB: Yes

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