Doppler Velocimetry of Umbilical Artery in Normal and Growth Restricted Pregnancy

ZAKIA AFROZE[1], ROKEYA BEGUM[2]

Abstract:

Objectives: To evaluate the umbilical arterial blood flow velocity and its various indices during 3rd trimester of pregnancy and to compare these indices in normal and growth restricted pregnancies.

Methods: In this study, 50 women with normal singleton pregnancy and 50 women with intrauterine growth restricted (IUGR) pregnancy with expected birth weight <10th percentile of the normal for the gestational age were studied by Doppler evaluation of their umbilical artery, Pulsality Index (PI), Resistance Index (RI) and S/D ratio of the control group and IUGR group were calculated and reference range constructed. Values of Doppler indices of IUGR group were compared with those of the control group. Perinatal outcome was evaluated in relation to the indices.

Results: Doppler velocimetry of umbilical artery showed elevated indices in 33 out of 50 cases of IUGR group showing its high sensitivity in diagnosing haemodynamically compromised growth restricted fetuses. Absent end diastolic velocly (AEDV) and reversed end diastolic velocity (REDV), were seen in 8 and 2 cases respectively and were associated with poor perinatal out come in terms of need for LSCS for fetal distress, Apgar score <7 at 1 minute, admission to NICU (Neonatal Intensive Care Unit) and perinatal death.

Conclusion: In normal pregnancy there is gestational age related fall in impedance in Umbilical arteries. Doppler study of umbilical artery is highly sensitive in the detection of IUGR and for the prediction of adverse perinatal outcome in small for gestational age.

Key Words: Doppler velocimetry, Pulsatility index (PI), Resistance Index (RI), S/D (Systolic/ Diastolic) ratio, Intrauterine Growth Restriction.

Introduction:

To reduce the perinatal morbidity and mortality of intrauterine growth restricted (IUGR) fetuses, their early detection and therapeutic intervention are important.[1]

Intrauterine growth restriction (IUGR) occurs in approximately 5-10% of all pregnancies.[2] The American College of Obstetrics and Gynaecology (ACOG) defines an IUGR fetus as a fetus with an estimated weight below 10th percentile.[3-4] IUGR refers to the fetus who is SGA (small for gestational age) and displays other signs of chronic hypoxia or malnutrition.[3-5]

The primary cause of growth restriction (FGR) has been reported to be placental in sufficiency in 60%

of pregnancies.[2-6] When chorionic villi vessels are injured, which leads to reduction in umbilical artery blood flow, Doppler index increases and in the end, there appears absent/reversed end diastolic blood flow.[2,7,8] In IUGR fetuses there exists strict correlation between the umbilical artery Doppler waveform and increased incidence of perinatal complications and particularly, absent/reversed end diastolic Umbilical arterial blood flow has been shown to be associated with high perinatal mortality, long term impairment of intellectual development and neuro-developmental delay.[2, 9-11]

When fetal growth retardation is diagnosed during the third trimester of pregnancy, the obstetrician must

1. Assistant Professor, Department of Obstetrics & Gynaecology, Cox's Bazar Medical College
2. Ex. Professor & Head, Department of Obstetrics & Gynaecology, Chittagong Medical College Hospital
Address of Correspondence: Dr. Zakia Afroze, A-4, Sanmar Sorrento, House No. 50/C, Road No. 3/A, North Khulshi, Khulshi Hills, Chattogram. Email: dr.zakiaafroze@gmail.com, Mobile: 01814310903

decide whether the fetus is 'constitutionally', small or small as a consequence of impaired placental perfusion[1]. Doppler flow velocity analysis can be valuable in resolving this question which led to better obstetric decision making.[1, 12,13]

Methods:

A cross sectional comparative study on "Doppler velocimetry of umbilical artery in normal and growth restricted pregnancy" was carried out in Chittagong Medical College Hospital at the department of Obstetrics and Gynaecology during the period of April 2010 to March 2011. The study population includes 50 women with singleton IUGR pregnancy as the study group (group-A) and 50 women with normal singleton pregnancy as the control group (group-B) and their gestational age ranged between 28-39 weeks.

Normal pregnant women with known date of last menstrual period and with no medical, surgical or obstetrical complications which can affect fetal growth, clinical examination as well as ultrasonography showed normal intrauterine fetal growth were included as control group. Known expected date of delivery, clinical discrepancy of symphysis fundal height of four weeks or more and ultrasonography showed fetal weight less than 10th percentile of their gestational age based on femur length (FL), biparietal diameter (BPD) and abdominal circumference (AC) were included as study group. Any woman with medical complication like, chronic hypertension, chronic nephritis, diabetes, heart disease etc. and one with obstetric complication like pregnancy induced hypertension, bad obstetrical history, hydramnios etc. were excluded from the control group, Congenital malformation of the fetus, uterine malformation, transverse lie, PROM were excluded from both the groups (study and control).

High definition image with a 3.5 MHz curvilinear transducer were used to obtain IUGR and Doppler wave form. BPD, FL, AC and AFI were measured and IUGR were corroborated. In the same sitting, Doppler flow velocimetry of umbilical artery was done and pulsatility index (PI), Resistance Index (RI), Systolic/Diastolic ratio (S/D ratio) were calculated. Women were divided into six groups of 28-29 weeks, 30-31 weeks, 32-33 weeks, 34-35 weeks, 36-37 weeks and 38-39 weeks of gestation. All the women were followed up until delivery. Perinatal outcome were evaluated following delivery and correlated with above values. Adverse perinatal outcome included low birth weight, Apgar score <7 at 1 and 5 minute, perinatal death and admission to NICU. Data obtained were analysed statistically using student t-test and chi-square test.

Results:

Maternal age and parity were similar in both the groups. In case of study group abnormal (reduced, absent/reversed) Doppler flow velocity was found in 66% of cases whereas it was only 6% in control group. Diagnosis to delivery interval was 6.8 days ± 10.5 SD in IUGR pregnancy and 36.9 days ± 22.82 SD in normal pregnancy. Most of the patients had caesarean delivery in the study group (IUGR Pregnancy) compared with control group (Normal Pregnancy) (Table-1).

Table-I
Characteristics of Patients

	Study Group (IUGR pregnancy) Group-A (N-50)	Control Group (Normal Pregnancy) Group-B (N-50)	P
Maternal Age	25.52 ± 4.56	24.78 ± 4.32	NS
Parity:			NS
Primiparity	46(46%)	32(32%)	
Multiparity	54(54%)	64(64%)	
Umbilical artarial blood flow velocity:			
Normal Doppler flow	17(34%)	47(94%)	0.000s
Abnormal Doppler flow	33(66%)	3(6%)	0.000s
Diagnosis-delivery Interval (days)	6.8 days ± 10.5 SD	36.9days ± 22.82 SD	0.000s
Cesarean rate	38(76%)	19(38%)	0.000s

NS= Not Significant
S=Significant

Umbilical arterial PI, RI, S/D ratio were calculated and reference values were constructed for comparison with study group. All indices showed progressive fall with advancing gestation in normal pregnancy suggestive of derease in peripheral impedance and increase in diastolic flow with progression of gestation in umbilical artery (Table II and III).

P. value of PI, RI, S/D ratio of the study group in comparison to the control group was <0.001 suggesting this to be highly significant (Table-IV).

There was absent end-diastolic flow in 8 (eight) subjects and reversed end-diastolic flow in 2 (two) subjects in study group. One subject with reversed end-diastolic velocity (REDV) of umbilical artery had still born and neonatal death occurred on 7th day of life in another case. Out of the 8 (eight) subjects with absent end-diastolic velocity (AEDV) of umbilical artery 3 (three) had IUD (intra uterine death), 2 (two) had neonatal death and 3 (three) of them survived. (Table-V). Abnormal Doppler flow (IUGR) was associated with poor perinatal outcome (Table VI).

Table-II

Umbilical artery Doppler indices in Group-A (n=50)

Period of Gestation (Weeks)	Number of Patient (N=50)	PI		RI		S/D Ratio	
		Mean	Upper Limit	Mean	Upper Limit	Mean	Upper Limit
28-29	2	2.08	2.08	1.00	1.00	-	-
30-31	2	1.93	1.93	1.00	1.00	-	-
32-33	8	1.78	2.26	0.86	0.99	4.66	6.07
34-35	10	1.27	1.61	0.74	0.85	3.58	4.47
36-37	12	1.38	2.03	0.72	0.85	3.16	3.73
38-39	16	1.01	1.19	0.62	0.70	2.75	3.31

Group A: Pregnancy with IUGR
PI-Pulsatility Index, RI-Resistance Index, S/D-Systolic/Diastolic
Upper Limit-Mean+ISD

Table-III

Umbilical artery Doppler indices in Group-B (n=50)

Period of Gestation (Weeks)	Number of Patient (N=50)	PI		RI		S/D Ratio	
		Mean	Upper Limit	Mean	Upper Limit	Mean	Upper Limit
28-29	6	1.05	1.21	0.66	0.71	3.01	3.45
30-31	7	1.00	1.05	0.66	0.69	2.95	3.19
32-33	8	0.99	1.13	0.63	0.68	2.75	3.14
34-35	11	0.94	1.06	0.61	0.65	2.62	2.90
36-37	11	0.93	1.00	0.59	0.63	2.50	2.70
38-39	7	0.91	0.99	0.58	0.62	2.44	2.64

Group B: Normal Pregnancy
PI-Pulsatility Index, RI-Resistance Index, S/D-Systolic/Diastolic
Upper Limit-Mean+ISD

Table-IV

Mean values of indices of umbilical artery (Doppler velocimetry) among the patients:

Doppler Indices	Group-A Mean ± SD(Range)	Group-B Mean ± SD(Range)	P-Value
Pulsatility Index (PI)	1.36 ± 0.51(0.72 - 2.78)	1.01 ± 0.17(0.70 - 1.55)	0.000 [S]
Resistance Index (RI)	0.74 ± 0.15(0.48 – 1.00)	0.63 ± 0.05(0.52 – 0.72)	0.000 [S]
Systolic/Diastolic (S/D) Ratio	3.28 ± 0.97 (1.91 – 6.50)	2.75 ± 0.35(2.07 – 3.56)	0.000 [S]

Group A: Pregnancy with IUGR; Group B: Normal Pregnancy,
P values reached from unpaired Student's t-tests;
[S]=Significant (P<0.001; P<0.01)

Table-V

Profile of women with AEDV/REDV

Umbilical arterial Blood flow velocity	Fetal Outcome	Birth Weight(g)	Apgar score at1 & 5 min	Admission in NICU	Perinatal Outcome
REDV at36 wks 3 days	Still Born at 36 wks 4 days LSCS	1400	-	-	-
REDV at 36 wks 2 days	AliveLSCS at 36 wks 2 days	1500	6 and 8	Needed	Death on7[th] day
AEDV at 29 wks 5 days	AliveLSCS at 30 wks	800	5 and 7	Needed	Death on2[nd] day
AEDV at 29 wks 4 days	AliveLSCS at 30 wks	700	5 and 7	Needed	Death on1[st] day
AEDV at 31 wks 1 days	AliveLSCS at 31 wks 1 days	1250	6 and 8	Needed	Survived
AEDV at 31 wks 3 days	AliveLSCS at 31 wks 5 days	1300	6 and 8	Needed	Survived
AEDV at 32 wks 2 days	AliveNVD at 32 wks 4 days	1200	4 and 7	Needed	Survived
AEDV at 33 wks 2 days	IUD NVD at 33 wks 3 days	1300	-	-	-
AEDV at 33 wks 3 days	IUD NVD at 33 wks 5 days	1250	-	-	-
AEDV at 35 wks 2 days	IUD NVD at 38 wks	1200	-	-	-

AEDV-Absent End Diastolic Velocity
REDV-Reversed End Diastolic Velocity
IUD-Intra Uterine Death
NVD-Normal Vaginal Delivery LSCS-Lower Segment Caesarean Section
NICU-Neonatal Intensive Care Unit

Table-VI

Parinatal outcome

	Study Group (IUGR pregnancy) Group-A (N-50)	Control Group (Normal Pregnancy) Group-B (N-50)	P
Gestational Age at delivery (week)	36.04 ± 2.56 SD	39.52 ± 0.65 SD	0.000
Mean birth weight (kg)	1.72 ± 0.41 SD	3.05 ± 0.32 SD	0.000
Apgar Score < 7at 1 min	36 (78.3%)	15 (30%)	0.009
At 5 min	13 (28.3%)	4 (8.0%)	
Need for NICU			
Admission	32 (69.6%)	0 (0.0%)	0.000
Perinatal deaths	7 (14%)	0 (0.0%)	0.023

NICU- Neonatal Intensive Care Unit

IUGR-Intra-Uterine Growth Retardation

Discussion:

The gestational age related decrease of the PI in the umbilical artery has been reported by many authors and reflects a reduction of flow resistance in the placental villous circulation. Wladimiroff et al. constructed the reference range for PI of umbilical artery in the third trimester[14]. The values calculated in our studies corroborate with the values of Wladimi-roff et al[14]. Lakhkar and Ahmed who calculated the mean RI values at different gestational age amongst the normal pregnant women to be 0.70 at 28 weeks and 0.65 at 37 weeks[15]. These are comparable to the RI values of present study of 0.66 and 0.59 at 28 and 37 weeks respectively. S/D ratio calculated by Khurana et al. was 3.07 at 28 weeks and 2.64 at 37 weeks corresponding to value of 2.95 at 28 weeks and 2.50 at 37 weeks of this study[13]. The values of PI, RI, S/D ratios in another study performed by Narula Harneet et al. was similar to present result[1].

Diastolic flow was seen to be reduced or even absent/reversed in growth restricted fetuses with consequent significant increases in PI, RI, S/D ratio values compared to normal fetuses by Wladimiroff et al. Lakhkar and Ahmad et al, Narula Harneet et al[1,14,15]. These increases were highly significant in present study also.

Torres et al in their retrospective study, reported that absence of end diastolic-flow was correlated with IUGR in 100% of pregnancies and fetal death by 66.6% which was similar with present study[16].

Doppler findings may be detected several hours to days before any abnormality in cardiotocographic tracings[17,18,19]. Assessment of EDF (end diastolic flow) is useful because when it is reduced it detect 30% severe hypoxia, when there is AEDF (absent end diastolic flow) is very worrying sign and detect 50% severe hypoxia and in case of REDF (reverse end diastolic flow) is ominous which detect 70% severe hypoxia and fetal death occur within 7 days[20]. The pregnancy could be continued even in the presence of AEDF for approximately 1 to 2 weeks with intensive fetal surveillance, this may provide time for adminis-tration of steroids to enhance fetal lung maturity and also the extra days may add to the fetal weight, also enables for shifting of the patient to a tertiary centre where proper neonatal care can be provided[17]. REDF is a terminal event associated with an extremely high perinatal mortality[17]. Immedi-ate delivery is advocated when REDF sets in usually within 24 hours of diagnosis and mainly the route of delivery is cesarean section in these pregnancies.

Conclusion:

Doppler velocimetry of umbilical artery (UA) is a rapid non invasive test that provides valuable information about the hemodynamic situation of the fetus. Various indices of umbilical artery velocimetry are PI (pulsatility index) RI (Resistance index) S/D ratio (Systolic/Diastolic ratio) which gradually decreases as pregnancy advances during normal pregnancy. In IUGR pregnancies these indices increases and at the end there appears absent and reversed end-diastolic flow. Applicability of Doppler indices in the diagnosis of abnormalities is possible only when there are reference normal values for each index. This study provides reference ranges of Doppler indices in tabulated form both for IUGR and normal pregnancy at 3rd trimester in our perspective. This would be helpful for obstetrician for obstetric decision making as well as for management of IUGR. In IUGR fetuses there exists strict correlation between the abnormal umbilical artery Doppler wave form and increased incidence of perinatal complications.

References:

1. Harneet N, Kapila AK, Kaur MM. Cerebral and umbilical arterial blood flow velocity in normal and growth restricted pregnancy. J Obstet Gynecol India Jan/Feb 2009; 59(1): 47-52.

2. Byun YJ, Kim HS, Yang JI, Kim JH, Kim HY, Chang SJ. Umbilical artery Doppler study as a predictive marker of perinatal outcome in preterm small for gestational age infants. Yonsei Med J 2009; 50(1):39-44.

3. Harkness UF, Mari G. Diagnosis and management of intrauterine growth restriction. American Journal of clinical Perinatology 2004 Dec; 31(4): 743-64.

4. American College of Obstetricians and Gynecologists. Intrauterine growth restriction. ACOG practice bulletin no. 12. Washing-ton, DC: American College of Obstetrics and Gynecologists; 2000.

5. Ville Y, Nyberg DA. Growth, Doppler and fetal assessment. In : Nyberg DA, Mc Gahan JP, Pretorius DH, Pilu G, editors. Diagnostic imaging of fetal anomalies. Philadelphia : Lippincott, Williams and Wilkins; 2003. p. 31-58.

6. Gagnon R, Van den Hof M; Diagnostic Imaging Committee, Executive and Council of the Society of Obstetricians and Gynaecologists of Canada. The use of fetal Doppler in obstet-rics. J Obstet Gynaecol Can 2003;25:601-14; 615-6.

7. Giles WB, Trudinger BJ, Baird PJ. Fetal umbilical artery flow velocity waveforms and placental resistance: pathological corre-lation. Br J Obstet Gynaecol 1985;92:31-8.

8. Morrow RJ, Adamson SL, Bull SB, Ritchie J.W. Effect of placental embolization on the umbilical arterial velocity waveform in fetal sheep. Am J Obstet Gynaecol 1989;161:1055-60.

9. Soregaroli M, Bonera R, Danti L, Dinolfo D, Taddei F, Valcamonico A, et al. Prognostic role of umbilical artery Doppler velocimetry in growth-restricted fetuses. J Matern Fetal Neonatal Med 2002;11:199-203

10. Brar HS, Plat LD. Reverse end-diastolic flow velocity on umbilical artery velocimetry in high risk pregnancies: an ominous finding with adverse pregnancy outcome. Am J Obstet Gynaecol 1988;159:559-61.

11. Wienerroither H, Steiner H, Tomaselli J, Lobendanz M, Thun-Hohenstein L. Intrauterine blood flow and long-term intellectual, neurologic and social development. Obstet Gynecol 2001;97:449-53.

12. Gramellini D, Folli MC, Robins et al. Cerebral umbilical Doppler ratio as a predictor of adverse perinatal outcome. Obstet Gynecol 1992; 79: 416-20.

13. Khurana A, Chawala J, Singh K. Normal systolic/diastolic ratios of the umbilical artery flow velocity waveforms in Indian pregnancies. Indian J Radiol Imaging 1995; 5: 25-8.

14. Wladimiroff JW, Vd Wijngaard, Degani S et al. Cerebral and umbilical arterial blood flow velocity waveforms in normal and growth restricted pregnancies. Obstel Gynaecol 1987; 69:705-9.

15. Lakhkar BN. Ahamad SA. Doppler velocimetry of uterine and umbilical arteries during pregnancy. Indian J Radiol Imaging 1999; 9:119-25.

16. Torres P J, Gratacos E, Alonso PL. Umbilical artery Doppler ultrasound predicts low birth weight and fetal death in hypertensive pregnancies. Acta Obstet Gynecol Scand 1995; 74(5): 352-5.

17. Tyrrell SN, Lilford RJ, Macdonald HN, Nelson EJ, Porter J, Gupta JK. Randomized comparison of routine vs highly selective use of doppler ultrasound and biophysical scoring to investigate high risk pregnancies. Br. J. Obstet Gynecol 1990; 97: 909-16.

18. Alonstrom H, Axelsson 0, Cnattingius S, Ekman G, Maesel A, Ulmsten U, et al. Comparison of umbilical-artery velocimetry and cardiotocography for surveillance of small for gestational age fetuses. Lancet 1992; 340: 936-40.

19. Kwek K. Lecture on intrauterine growth retardation. Consultant, Department of maternal & fetal medicine, KK Women's and Children's Hospital, Singapore. Dated-15.09.2005.

20. GRIT Study group. When do obstetricians recommend delivery for a high-risk preterm growth-restricted fetus? Eur J Obstet Gynecol Reprod Biol 1996; 67: 121-6.