An Observational Study to Assess the Role of Uterine Artery Doppler in Prediction of Intrauterine Foetal Growth Restriction.

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ABSTRACT

Background: The present study was planned to assess the role of uterine artery Doppler in the prediction of IUGR and Pre-eclampsia in the department of obstetrics and Gynaecology at NIMS Medical College during a span of one year (Nov 2013-Oct 2014). **Methods:** One hundred pregnant women with singleton pregnancy at 18-20 weeks period of gestation were subjected to uterine artery Doppler study and later repeated at 24-26 weeks of gestation. **Results:** It was observed that 38% patients had abnormal outcome with 20% patients with IUGR , 12% with PE, 6% with both IUGR and PE. **Conclusion:** By inclusion of uterine artery Doppler study in routine practice and timely intervention fetomaternal morbity and mortality can be greatly reduced.

Keywords: Intrauterine Doppler, Intrauterune growth retardation, Pre-eclampsia.

INTRODUCTION

Intrauterine growth restriction (IUGR) is defined as a foetus is growth retarded if its weight is below the tenth percentile for its gestational age[1,2] Any foetus that does not reach his/her intra uterine growth potential is defined as growth restricted[3] In a population of healthy well-nourished women, IUGR occurs in approximately 3-5% of the patients.[4]

In a population of women at high risk, such as women with hypertension or previously growth restricted foetus, the prevalence rises to 25% or higher.[4] These growth restricted foetuses have four to eight fold increased risk of Perinatal mortality compared to appropriately sized foetuses. Of the foetuses that survive 50% have short term morbidity such as intra partum foetal distress, hypoglycaemia, hypocalcaemia and meconium aspiration pneumonia.[5-9] Long term problems like psychomotor problems as well as increased risk of developing diabetes and hypertension occur later in life.[10,11] Although numerous maternal and foetal etiologies may result in IUGR, placental insufficiency is the most common pathway leading to impaired oxygen and nutrient transport to foetus.

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The uterine artery blood reflects hemodynamic changes that occur on the maternal side of the placenta.[1] Doppler ultrasonography has emerged as a non-invasive tool to assess the hemodynamic status of the maternal, foetal and uteroplacental vasculature, hence it is very useful in evaluation of IUGR. In obstetrics, Doppler ultrasound measures the change in frequency of sound energy reflected from red blood cells and other substances in the maternal and foetal circulations. The velocity of blood flow during the cardiac cycle determines the frequency shift of the Doppler signal and the shape of the waveform. The peak systolic velocity is a measure of blood flow velocity and is dependent on cardiac output. The velocity at the end of diastole (end diastolic flow) is dependent on vessel wall, heart rate and vascular impedance and is useful in the management of conditions that result in placental insufficiency. The indices most commonly used to express the Doppler phenomenon are systolic–to-diastolic (S/R) ratio, Resistance index (RI) and Pulsatility Index .With this background the present study was undertaken to assess the role of uterine artery Doppler in prediction of IUGR.

MATERIALS AND METHODS

The study was cross-sectional, observational, descriptive type study. A population of 100 pregnant women with singleton pregnancy at 18 to 20 weeks period of gestation with known LMP or first trimester ultrasound were included. Women with unknown gestational age or with no early date ultrasound scan, chronic hypertension, diagnosed cases of symmetrical IUGR (by ultrasound scan done at 18-20 weeks), and multiple gestations were not included.

Pregnant women in 2nd trimester at 18-20 weeks of gestation attending antenatal clinic for anomaly scan were screened for eligibility by a detailed history and routine antenatal examination. The mandatory and required consent of the patient on the prescribed proforma for the ultrasound imaging

as per PC & PNDT law was obtained. With ultrasonography, foetal biometry and morphology (anomaly) scan was done using VOLUSON GE 730 PRO machine with the 3.5 MHz curvilinear probe. The same observer examined patients always. Patient was put in recumbent position with the empty bladder. The vessels evaluated by the doppler method were the right and left uterine arteries. The flow velocity waveforms on the right and left uterine arteries were taken when 3 or 4 waves of equal height were seen, the image was frozen and measurements were taken either by trace method/ manually/automatic trace. The impedance indexes used was Resistance Index (RI) and presence or absence of diastolic notch was noted. Resistance index of more than 0.56 and the presence of notch in the uterine arteries was considered as an abnormality in the flow velocity waveform. Women who had a diastolic notch at 18 to 20 weeks scan underwent repeat Doppler at 24-26 weeks to see the persistence of the diastolic notch. All women were subjected to a growth scan along with doppler studies of the umbilical arteries at 34-37 weeks of gestation to detect IUGR. These patients were followed up till delivery and details of pregnancy events, delivery and neonatal outcomes were noted.

Statistical Analysis

A Continuous variable were summarized as Mean ± Standard Deviation (SD) while Nominal/Categorical variables as Percentages. The diagnostic accuracy of diastolic notch and RI was determined by calculating sensitivity, specificity, positive predictive value (PPV) and negative predictive value (NPV).Association between Nominal/Categorical variables was assessed using Chi-square Test. P value < 0.05 was taken as significant. Med calc. 14.0.0 version software was used for statistical calculations.

The indices are:-[14,15]

1. S/D ratio:
$$\text{S/D ratio} = \frac{\text{Peak Systolic Velocity}}{\text{End diastolic Velocity}} = \frac{A}{B}$$

2. Resistance Index (RI):
$$\text{RI} = \frac{\text{Peak Systolic-End Diastolic}}{\text{Peak Systolic Velocity}} = \frac{A-B}{A}$$

Table 1: Uterine artery Doppler – RI findings at 18 to 20 weeks

RI	Right		Left		Bilateral	
	No.	%	No.	%	No.	%
>0.56(High)	41	41.00	39	39.00	22	22.00
< 0.56 (Normal)	59	59.00	61	61.00	78	78.00
Total	100	100.00	100	100.00	100	100.00

Figure 1: RI value in relation with right, left and both uterine arteries.

Figure 2: Presence of diastolic notch in relation with right, left and both uterine arteries.

In this study at 18 to 20 weeks, the right uterine artery RI was abnormal (high) in 41.00 % women and left uterine artery RI was abnormal in 39.00% women, with 22.00% women showing abnormal high RI in both the arteries. The mean right UA RI was 0.53 ± 0.13 and left UA RI was 0.52 ± 0.12 [Table 1; Figure 1].
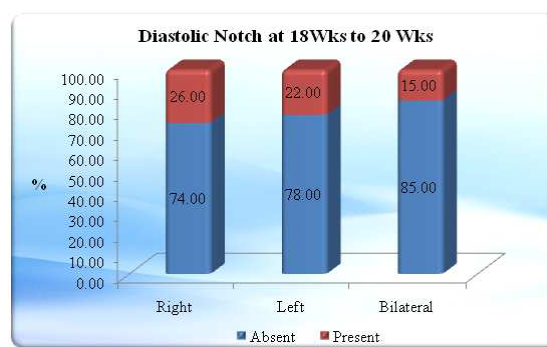
In the present study, right diastolic notch was present among 26.00% women and left diastolic notch was seen in 22.00% of women, with bilateral notches seen in 15.00% cases [Table 2; Figure 2].

Table 2: Uterine artery Doppler – Presence of diastolic notch at 18 to 20 weeks

Notch	Right		Left		Bilateral	
	No.	%	No.	%	No.	%
Absent	74	74.00	78	78.00	85	85.00
Present	26	26.00	22	22.00	15	15.00
Total	100	100.00	100	100.00	100	100.00

Table 3: Uterine artery Doppler – Persistence of abnormal RI findings at 24 to 26 weeks

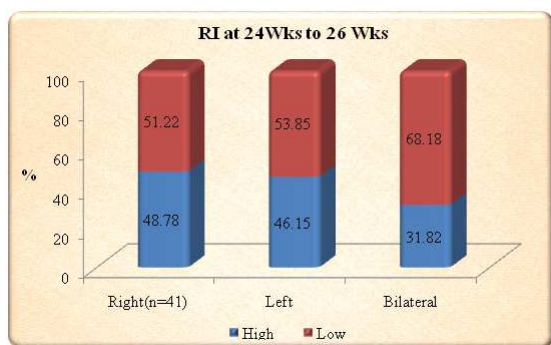| RI	Right		Left		Bilateral	
	No.	%	No.	%	No.	%
High	20	48.78	18	46.15	7	31.82
Low	21	51.22	21	53.85	15	68.18
Total	41	100.00	39	100.00	22	100.00

Figure 3: RI values in relation with right, left and both uterine arteries.
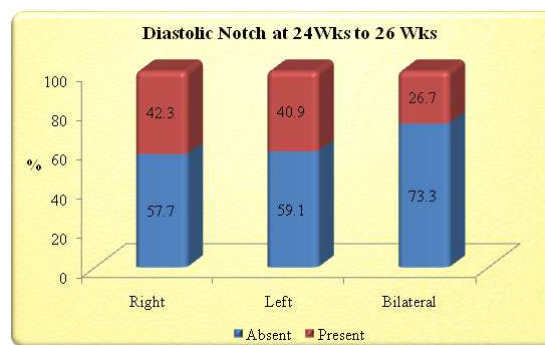

Figure 4: Presence of diastolic notch in relation with right, left and both uterine arteries.

In this study at 24 to 26 weeks, of the 41 women with abnormal Uterine Artery (UA) RI findings on the right, 20 (48.78%) had abnormal findings whereas of the 39 women with abnormal left UA RI previously, 18 (46.15%) had abnormal left uterine artery RI. Of the 22 women with abnormal RI findings in both the arteries previously (31.82%) had persistence of abnormal findings. The mean right UA RI was 0.48 ± 0.13 and left UA RI was 0.51 ± 0.10 [Table 3,4; Figure 3].

In the present study at 24 to 26 weeks, of the 26 women with right diastolic notch during previous scan, persistence of right diastolic notch was seen among 11 (42.30%) whereas in 9 (40.9%) of the 22 women who had revealed left diastolic notch on previous scan had persistence of left diastolic notch. Of the 15 women, having bilateral diastolic notch previously (26.7%) showed persistence of the notch [Figure 4].

Table 4: Uterine artery Doppler – Persistence of abnormal RI findings at 24 to 26 weeks

Notch	Right (n=26)		Left (n=22)		Bilateral (n=15)	
	No.	%	No.	%	No.	%
Absent	15	57.70	13	59.1	11	73.3
Present	11	42.30	9	40.9	4	26.7
Total	26	100.00	22	100.00	15	100.00

Table 5: Uterine artery Doppler – Persistence of abnormal RI findings at 24 to 26 weeks

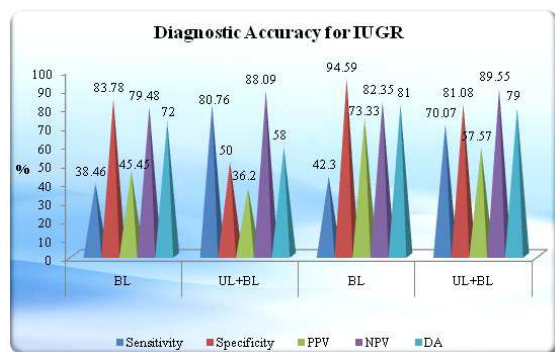| Intrauterine growth restriction		Sensitivity	Specificity	PPV	NPV	DA
RI	BL	10/26	62/74	10/22	62/78	72/100
		38.46%	83.78%	45.45%	79.48%	72.00%
	UL+BL	21/26	37/74	21/58	37/42	58/100
		80.76%	50.00%	36.20%	88.09%	58.00%
Diastolic Notch	BL	11/26	70/74	11/15	70/85	81/100
		42.30%	94.59%	73.33%	82.35%	81.00%
	UL+BL	19/26	60/74	19/33	60/67	79/100
		70.07%	81.08%	57.57%	89.55%	79.00%

Figure 5: Diagnostic accuracy of IUGR in relation with right, left and both uterine arteries.

The diagnostic accuracy of uterine artery doppler for prediction of IUGR by high RI in either of the uterine arteries is 58% with sensitivity of 80.76% and specificity of 50.00% with PPV of 36.20% and NPV of 88.09% compared to same parameters obtained by bilateral diastolic notching are 81%, 42.30%, 94.59%, 73.33% and 82.35% respectively [Table 5, 6].

DISCUSSION

Normally uterine artery shows a diastolic notch, which disappears by 24 - 26 weeks of pregnancy. The aim of our study was to find out the correlation between presence of uterine artery notch and high RI in development of IUGR and preeclampsia and whether doppler assessment helps in identifying these high-risk pregnancies early and improve their management and outcome.

In our Observational Study done over a period of one year among 100 pregnant women attending the outpatient department for antenatal care who underwent an anomaly scan in second trimester between 18-20 weeks were also subjected to bilateral uterine artery doppler. Patients underwent repeat doppler between 24-26 weeks to see the persistence of the diastolic notch and abnormal high RI. All women were subjected to a growth scan at 34-37 weeks of gestation to detect IUGR.

In the present study, during the second trimester at 18-20 weeks, 41.00% women had abnormal right UA RI and 39.00% of women had abnormal left uterine artery RI, thus 58 % of the women had abnormal high RI > 0.56 in either right or left uterine artery which is same as compared to Coleman et al[17] (67.2%) and Martin et al[22] (55.5%) and more as compared to Steel et al[16](11.6%), North et al[14] (12.3%), Kurdi et al[18] (22.8%), Irion et al[21] (12.8%). The mean right UA RI was 0.53 ± 0.13 and left UA RI was 0.52 ± 0.12. The right diastolic notch was present among 26.00% women while, left diastolic notch was seen in 22.00% of women and the bilateral notch was seen among 15.00% of women. Thus 15.00% of the women had bilateral notching at 18 -20 weeks

which is less than Gomez et al[20] (29.5%) and Aggarwal et al[19] (32.07%).

In this study on repeat doppler at 24-26 weeks, abnormal UA RI findings on right persisted among 48.78% of women while, left abnormal UA RI persisted among 46.15%. Of the 22 women with abnormal RI findings in both the arteries previously, 7 (31.82%) had persistence of abnormal findings. Overall, the mean right UA RI was 0.48 ± 0.13 and left UA RI was 0.51 ± 0.10. Of the 26 women with right diastolic notch during previous scan, persistence of right diastolic notch was seen among 11 (42.30%) and of the 22 women who had left diastolic notch during previous scan, 9 (40.9%) had persistence of left diastolic notch. Of the 15 women having bilateral diastolic notch, 4 (26.7%) showed persistence of the notch. Overall, of the 100 women, the diastolic notch was present in 24.00% women.

Mean RI in our study for left and right sided uterine arteries is 0.60 and 0.55 for those who developed IUGR 0.54 and 0.55 for those who developed Pre-eclampsia. Of the 58.00 % cases with abnormal RI at 18-20 weeks 31.00% cases had persistence of abnormality at 24- 26 weeks, of which 21(36.20%) cases developed IUGR which is statistically significant with p=0.012, while 12 (20.69%) cases developed PE with p value of 0.576 that is statistically not that significant. Hence sensitivity of abnormal high Resistance index is (80.76%), specificity is (50.00%), positive predictive value is (36.20%), Negative predictive value is (88.09%) and Diagnostic accuracy (58.00%) in prediction of IUGR similar to Coleman et al[17] and Aggarwal et al.[19] [Table 6].

Table 6: Comparison of sensitivity, specificity, PPV and NPV of uterine artery doppler study in IUGR with other studies.

Authors	Sensitivity	Specificity	PPV	NPV
Coleman et al	84	39	33	87
Agarwal et al	84	71.4	72.4	
Our study	80.76	50	36.2	88.09

When uterine artery notch both (Unilateral and Bilateral) at 18– 20 weeks is considered 57.57% of the women developed IUGR and 42.42% developed PE which are both statistically highly significant p<0.001. Thus sensitivity (70.07%), specificity(81.08%), PPV(57.57%), NPV(89.55%) and diagnostic accuracy(79.00%) in prediction of IUGR and for preeclampsia sensitivity (77.77%), specificity (76.82%), PPV (42.42%), NPV (90.02%) and diagnostic accuracy (77.00%).

In our study out 100 women 15 patients had bilateral notching at 18-20 weeks, of which 11 (73.33%) developed IUGR and 9 (60.00%) developed PE both of which are statistically highly

significant p<0.001. Hence sensitivity of bilateral uterine artery notching is 42.30%, specificity is 94.59% positive predictive value is 73.33% ,negative predictive value is 82.35% and diagnostic accuracy 81.00% in prediction of IUGR similar to Kurdi et al,[18] Coleman et al,[17] Gomez et al,[20] Llrurba et al.[24]

Doppler velocimetry is a non-invasive technique, which uses high frequency sound for investigation of blood flow. The feasibility of its foetal application was first reported by Fitzgerald and Drumm.[12] It made possible non-invasive investigation of uteroplacental circulation. Normal uterine artery has a complex wave form in a non pregnant state showing a steep systolic notch and an early diastolic notch with small amount of diastolic flow indicating high vascular resistance.[13] Approximately 4 weeks after implantation well defined low resistance vessels are seen at the site of future placenta.[23] Most dramatic changes are seen in second trimester when there is uncoiling of main uterine and spiral arteries.[25] As pregnancy progresses it changes to a low resistance vessel and there is gradual removal of notch, increase in diastolic flow, and fall in RI.

CONCLUSION

- The present study showed that the diagnostic accuracy of uterine artery doppler for prediction of IUGR by high RI in either of the uterine arteries is 58% with sensitivity of 80.76% and specificity of 50.00% with PPV of 36.20% and NPV of 88.09% compared to same parameters obtained by bilateral diastolic notching are 81%, 42.30%, 94.59%, 73.33% and 82.35% respectively.

- Women with normal impedance to flow in the uterine arteries constitute a group that have a low risk of developing obstetric complications related to uteroplacental and fetoplacental insufficiency.

- Uterine artery doppler should be included in hospitals with facilities and infrastructure to identify a group of patients at risk of developing IUGR.

REFERENCES

1. Baker DW. Pulsed ultrasonic Doppler blood flow sensing IEEE Trans sonic Ultrasonics. 1970;17(3):170-185.
2. Galbraith RS, Karchmar EJ, Piercy WN, Low JA. The clinical prediction of intrauterine growth retardation. Am J Obstet Gynecol. 1979;133(3): 281-6.
3. Elisa A et al. Manual of neonatal care, 6th edition, 1:4.
4. Tejani NA. Recurrence of intrauterine growth retardation. Obstet Gynecol. 1982;59(3):329-31.
5. Doctor BA, O'Riordan MA, Kirchner HL, Shah D, Hack M. Perinatal correlates and neonatal outcomes of small for gestational age infants born at term gestation. Am J Obstet Gynecol. 2001;185(3):652-9.
6. Kramer MS, Olivier M, McLean FH, Willis DM, Usher RH. Impact of intrauterine growth retardation and body proportionality on fetal and neonatal outcome. Pediatrics. 1990;86(5):707-13.
7. Hakanson DO, Oh W. Hyperviscosity in the small-for-gestational age infant. Biol Neonate. 1980;37(1-2):109-12.
8. Ferguson AC. Prolonged impairment of cellular immunity in children with intrauterine growth retardation. J Pediatr. 1978;93(1):52-6.
9. Yanney M, Marlow N. Paediatric consequences of fetal growth restriction. Semin Fetal Neonatal Med. 2004;9(5):411-8.
10. McCarton CM, Wallace IF, Divon M, Vaughan HG Jr. Cognitive and neurologic development of the premature, small for gestational age infant through age 6:comparison by birth weight and gestational age. Pediatrics. 1996;98(6):1167-78.
11. O'Keeffe MJ, O'Callaghan M, Williams GM, Najman JM, Bor W. Learning, cognitive, and attentional problems in adolescents born small for gestational age. Pediatrics. 2003;112(2):301-7.
12. FitzGerald DE, Drumm JE. Non-invasive measurement of human fetal circulation using ultrasound: a new method. Br Med J. 1977;2:1450-1.
13. Campbell S, Diaz-Recasens J, Griffin DR, Cohen-Overbeek TE, Pearce JM, Willson K, Teague MJ. New doppler technique for assessing uteroplacental blood flow. Lancet. 1983;1:675-7.
14. North RA, Ferrier C, Long D, Townend K, Kincaid-Smith P. Uterine artery Doppler flow velocity waveforms in the second trimester for the prediction of preeclampsia and fetal growth retardation. Obstet Gynecol. 1994;83(3):378-86.
15. Low JA. The current status of maternal and fetal blood flow velocimetry.Am J Obstet Gynecol. 1991;164(4):1049-63.
16. Steel SA, Pearce JM, McParland P, Chamberlain GV. Early Doppler ultrasound screening in prediction of hypertensive disorders of pregnancy. Lancet. 1990;30:1548-51
17. Coleman MA, McCowan LM, North RA. Mid-trimester uterine artery Doppler screening as a predictor of adverse pregnancy outcome in high-risk women. Ultrasound Obstet Gynecol. 2000;15(1):7-12.
18. Kurdi W, Campbell S, Aquilina J, England P, Harrington K. The role of color Doppler imaging of the uterine arteries at 20 weeks' gestation in stratifying antenatal care. Ultrasound Obstet Gynecol. 1998;12(5):339-45.
19. Agrawal P, Agrawal RK, Agrawal MC. Persistent uterine artery notch – A predictor of intrauterine growth retardation and pregnancy induced hypertension. J Obstet Gynecol India. 2006;56(4):301-3.
20. Gómez O, Martínez JM, Figueras F, Del Río M, Borobio V, Puerto B, Coll O, Cararach V, Vanrell JA. Uterine artery Doppler at 11-14 weeks of gestation to screen for hypertensive disorders and associated complications in an unselected population. Ultrasound Obstet Gynecol. 2005;26(5):490-4.
21. Irion O, Massé J, Forest JC, Moutquin JM. Prediction of pre-eclampsia, low birthweight for gestation and prematurity by uterine artery blood flow velocity waveforms analysis in low risk nulliparous women. Br J Obstet Gynaecol. 1998;105(4):422-9.
22. Martin AM, Bindra R, Curcio P, Cicero S, Nicolaides KH. Screening for pre-eclampsia and fetal growth restriction by uterine artery Doppler at 11-14 weeks of gestation. Ultrasound Obstet Gynecol. 2001;18(6):583-6.
23. Deutinger J, Rudelstorfer R, Bernaschek G. Vaginosonographic velocimetry of both main uterine arteries by visual vessel recognition and pulsed Doppler method during pregnancy. Am J Obstet Gynecol. 1988;159(5):1072-6.

24. Llurba E, Carreras E, Gratacós E, Juan M, Astor J, Vives A, et al. Maternal history and uterine artery Doppler in the assessment of risk for development of early- and late-onset preeclampsia and intrauterine growth restriction. Obstet Gynecol Int. 2009;20:117-122.
25. Bewley S, Campbell S, Cooper D. Uteroplacental Doppler flow velocity waveforms in the second trimester. A complex circulation. Br J Obstet Gynaecol. 1989;96(9):1040-6.