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Original Research Article

Role of Doppler Analysis of Uterine Artery in the Assessment of Uteroplacental and Foetal Circulation

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Abstract:

Background: Pregnancies complicated by hypertension and intrauterine growth retardation (IUGR) experience a reduction in uteroplacental blood flow. It may be possible to predict the onset of these conditions by measuring uteroplacental blood flow early in pregnancy with colour Doppler because this decline is linked to a pathologic condition of spiral arteries that is thought to arise during placentation in the first trimester of pregnancy. This study was therefore undertaken to analyse the utilization of uterine artery Doppler imaging in the assessment of uteroplacental and foetal circulation.

Methods: Serial Doppler evaluation of the uterine artery was done at 3 weeks' interval. For patients with abnormal Doppler parameters, serial evaluation was done at 1 week and less frequent intervals depending on the severity. Doppler values of the last examination were taken for statistical measurements. The measurements of systolic/ diastolic ratio, resistance index and pulsatility index were made. Abnormal results were observed as a decrease in diastolic flow with resultant increased values of S/D, resistance index and also the characteristic persistent diastolic notch. A confidence interval was considered in S/D, resistance index and pulsatility index at different age groups by taking mean ± standard deviation. Chi – square test was applied to detect the weightage of the variable in multiple outcomes. The probability concept was directly applied to determine sensitivity, specificity and predictive values.

Results: When compared to normal Doppler, higher S/D, RI and PI values were found in the abnormal Doppler.

Conclusion: Doppler velocimetry of the uterine artery is one of the best prenatal tools in the earlier detection of the intrauterine growth retardation that may require additional antepartum surveillance and early obstetric intervention.

Introduction

Analysis of uterine artery by Doppler has evolved as an important tool in the armamentarium for the assessment of uteroplacental and foetal circulation and foetal well-being. Pregnancies complicated by hypertension and intrauterine growth retardation (IUGR) experience a reduction in uteroplacental blood flow. It may be possible to predict the onset of these conditions by measuring uteroplacental blood flow early in pregnancy with colour Doppler because this decline is linked to a pathologic condition of spiral arteries that is thought to arise during placentation in the first trimester of pregnancy. [1]

Numerous research conducted in the 1990s and the early 2000s found a direct link between a high blood flow resistance in the uterine arteries and a higher risk of pregnancy problems. However, the test's sensitivity and positive predictive value were insufficient for predicting unfavourable pregnancy outcomes. [2] This study was therefore done to analyse the utilization of uterine artery Doppler imaging in the assessment of uteroplacental and foetal circulation.

Measurements of the uterine artery are usually done in the lower lateral quadrant of the abdomen, when an apparent crossover between the external iliac artery and the main uterine artery can be easily visualised. Studies on the major uterine vessels are more likely to offer a comprehensive picture of placental perfusion because these measures are more repeatable and the vessels reflect the whole resistance of the placental bed.

Materials & Methods

In 100 instances with clinically and sonographically proven intrauterine growth retardation in the age range of 18–35 years, after 30 weeks of gestation, this prospective study was carried out at Government Medical College, Thrissur, Kerala, between July 2003 and September

2004. The most accurate estimation of gestational age was made using the menstrual history, clinical gestational age, or foetal biometry in the first or early second trimester.

ATL's real-time colour Doppler ultrasound system (ATL - APOGEE 800), used in the Department of Radiodiagnosis at the Medical College of Kerala in Thrissur, was used for the obstetric ultrasonography and Doppler examinations. All the patients were monitored up to delivery, and the pregnancy's outcome-including any intrauterine deaths, the type of labour, perinatal or neonatal deaths, the baby's birth weight, and its Apgar score-was meticulously documented. All of these details were entered in a proforma. Finally, the data was statistically analysed and evaluated. The procedure of obstetric ultrasound examination and Doppler evaluation are described below.

Doppler Evaluation

All the Doppler studies were done with the patient adequately relaxed and resting. The results were compared with the normal values described by Harold Schulman and Zeev Weiner. [3] For the assessment of uterine artery, the transducer was placed in the lower lateral quadrant of the uterus and angled medially. The characteristic crossover of external iliac artery and main uterine artery was studied consistently. The cursor was placed in the artery, sample volume size adjusted and an optimum Doppler signal obtained. The measurements of systolic/ diastolic ratio, resistance index and pulsatility index were made. For all patients, serial Doppler measurements were done till a decision for termination of pregnancy was taken. For normal cases, serial Doppler evaluation was done at 3 weeks' interval. For patients with abnormal Doppler parameters, serial evaluation was done at 1 week and less frequent intervals depending on the severity. Doppler values of the last examination were taken for statistical measurements.

The results of the Doppler studies were compared with normal values.

Uterine artery	S/D	RI
28 weeks	2.5	0.54
32 weeks	2.2	0.5

Abnormal results were observed as a decrease in diastolic flow with resultant increased values of S/D, resistance index and also the characteristic persistent diastolic notch.

A confidence interval was considered in S/D, resistance index and pulsatility index at different age groups by taking mean ± standard deviation. Chi – square test was applied to detect the weightage of the variable in multiple outcomes. The probability concept was directly applied to determine sensitivity, specificity and predictive values.

Results: In patients with an abnormal Doppler, the Doppler values higher when compared to the average values in the study population as a whole, as well as those with a normal Doppler.

Table 1: S/D, RI, PI values of uterine artery

	S/D		RI		PI	
	M	SD	M	SD	M	SD
All 100 patients	2.6469	0.8954	0.595	0.1173	1.4826	0.3729
Normal Doppler	2.044	0.3413	0.5158	0.0851	1.3305	0.2340
Abnormal Doppler	2.770	0.9243	0.6112	0.1167	1.513	0.3892

When comparing the abnormal Doppler to the normal Doppler, significant changes in S/D, RI, and PI values were found. S/D ratio increased from 2.04 to 2.77, RI increased from 0.51 to 0.61, and PI increased from 1.33 to 1.51.

Table 2: S/D, RI and PI of uterine artery in the weeks 30 to 40

Weeks	uterine artery Doppler		
	S/D	RI	PI
30	2.74±0.786	0.629±0.125	1.665±0.3341
31	2.436±1.197	0.628±0.152	1.63±0.422
32	2.99±1.394	0.6291±0.133	1.583±0.496
33	2.786±0.735	0.597±0.116	1.383±0.496
34	2.372±0.658	0.56±0.117	1.350±0.309
35	2.302±0.423	0.554±0.083	1.365±0.376
36	2.548±0.721	0.579±0.121	1.449±0.338
37	3.386±1.606	0.63±0.119	1.504±0.2625
38, 39, 40	2.8±0.797	0.6166±0.1093	1.57±0.209

Discussion

This study examined the relationship between uterine artery Doppler abnormalities in intrauterine growth retardation and abnormal pregnancy outcome. A total of 100 patients with clinical intrauterine growth retardation were studied. Out of the 100 patients, 83 were found to have both abnormal fetometry on ultrasound and abnormal Doppler findings. Serial follow-up revealed that 17 individuals had abnormal fetometry but normal Doppler results. Analysis was conducted using the final Doppler result obtained before delivery.

The impairment of blood supply to the placenta can be assessed by Doppler sonography of the uterine artery. The presence of a notch and elevated resistance index (>0.58) or pulsatility index with advancing gestation is an indicator of increased uterine vascular resistance, impaired uterine blood flow and abnormal placentation.

In our study, significant changes of S/D, RI and PI values in the abnormal Doppler were observed when compared to normal Doppler. Increase in the S/D value from 2.04 to 2.77, RI from 0.51 to 0.61 and PI from 1.33 to 1.51 were noted as shown in Table 1. These values indicate an adverse neonatal outcome, as shown by the earlier studies. We further studied these values at weekly intervals from 30 to 40 weeks, as shown in Table 2. We did not observe a particular pattern of the changes in these values, although the values were higher compared to normal at each of these time points of observation.

According to Trudinger BJ et al. [4] there is little end diastolic flow in the branches of the arcuate arteries during the first trimester. A low volume, high resistance circulation gradually changes to a large volume, low resistance circulation. Beginning in the second trimester, there is a noticeable rise in end diastolic flow rates, which causes the S/D ratio to fall. The typical uteroplacental ratio should be 2 or below 55 (with a maximum of 2.6) after 24 to 26 weeks of gestation.

Fleischer and associates [5] defined a normal value for combined left-right uterine A waveform and designated a S/D ratio of greater than 2.6 from 26 weeks onward as abnormal. When the ratio exceeded this, there was usually a notch in the waveform, and maternal pre-eclampsia, stillbirths, premature birth and intrauterine growth retardation complicated the pregnancies 56. This abnormal waveform preceded the onset of disease. Schulman et al [6] evaluated the left and right uterine arteries independently. An abnormal difference between the two (the difference between the two vessels should not exceed one) – showed an association with earlier gestational age at delivery, lower foetal weight, and a higher incidence of pregnancy induced hypertension, proteinuria, and intrauterine growth retardation when compared to controls. This difference was shown to have an adverse impact on the pregnancy, even when the S/D ratio was normal.

Kofinas et al [7] found that in both normal and hypertensive pregnancies, the flow indices (S/D ratio) of the uterine artery on the same side as the placenta were significantly lower than the contralateral artery. A centrally located placenta demonstrated similar indices on both sides. Later the relationship between pregnancy outcome and vascular resistance in both the uterine arteries was evaluated. In patients with unilateral placentas, the placental uterine artery was found to be a better predictor of poor pregnancy outcome than the non-placental uterine artery or the mean of the two arteries.

The uterine artery flow velocity waveform associated with hypertension frequently has a steep upward slope to the systolic peak and an early diastolic notch. Impaired uterine artery flow velocity is identified by persistent abnormal indices, persistent diastolic notch after 24 to 26 weeks and a significant difference between the indices in the two vessels. Adverse outcomes associated with an abnormal uterine artery flow velocity waveform include pre-eclampsia and foetal growth retardation and its sequelae.[3]

The uterine artery that runs right beneath the placenta will see the earliest disappearance of the diastolic notch. Tissue invasion by trophoblasts is thought to be the cause of this. Most women will experience a hypertensive pregnancy problem if the notch has been eliminated by 24 to 26 weeks of pregnancy. Persistence of a notch in the early diastolic portion of the main uterine artery waveform after 24 to 26 weeks gestation is the best parameter for the prediction of moderate to severe pre-eclampsia.

According to Truginger B. J. et al., [4] umbilical arterial waveform analysis is the best method for predicting foetal growth retardation caused by foetal abnormalities as opposed to growth retardation caused by maternal conditions like pre-eclampsia or hypertension. The most significant abnormality of the wave form associated with an abnormal outcome is the diastolic notch. The notch predicts a bad outcome far more accurately than the resistance index by itself.

In the current investigation, it was shown that 9 out of the 83 abnormal Doppler instances in the analysis of the uterine artery study involved uterine notching. It was noted that uterine notching was an indicator of pregnancy – induced hypertension. The sensitivity of the association of uterine notching with pregnancy induced hypertension was 88.88%, with a specificity of 54.05%. Trudinger B J et al [4] also noted that the most significant abnormality of

the uterine artery waveform with an abnormal outcome was the diastolic notch and that the persistent uterine notch was associated with the development of hypertension in most of the pregnant patients. Similarly, Montenegro et al [8] noted a sensitivity of 100% and specificity of 82% in the detection of pre-eclampsia in high risk populations with persistent diastolic notch.

In our study, it was noted that of the 9 cases with persistent uterine notch after 26 weeks, there were 3 cases of neonatal deaths, 2 intrauterine deaths, and 2 cases of intensive care unit admission and 2 cases without any complications.

In the present study, the sensitivity of abnormal resistance index (>0.58) in the uterine artery for detecting abnormal outcome was 68.18% and specificity was 46.42% with a positive predictive value of 50% and a negative predictive value of 65% This was similar to the study by Jacobson et al [9] who obtained a sensitivity of 71% and a positive predictive value of 36%. Bower et al [10] noted a sensitivity of 78% and specificity of 96% for abnormal uterine artery wave form with elevated resistance index (>0.58) and persistent diastolic notch.

The typical uteroplacental ratio (S/D) should be 2 or less after 24 to 26 weeks of gestation. [10] In the present study, the sensitivity of a high S/D (upper limit 2.6) in the uterine artery and its specificity in detecting abnormal outcome were noted as 73.68% and 58.14% with a positive predictive value of 70% and negative value of 62.5%. This was similar to the study by Valensise et al [11] who obtained a sensitivity of 66% and positive predictive value of 53% (specificity 95%, negative value of 97%).

Campbell et al [12] found that the sensitivity and specificity of an abnormal uterine artery flow velocity waveform were 68% & 69% respectively 7, which were comparable to the values of 73.6% and 58.1% that were obtained in our study for uterine artery S/D >2.6 and values of 68.1% and 46.4% for a resistance index>0.58. Schulman et al [6] reported similar results with a positive predictive value of 78% for intrauterine growth retardation and hypertension. Harrington et al [13] also noted a significant correlation between uterine artery Doppler velocimetry and pregnancy induced hypertension with a sensitivity of 76% for an abnormal resistance index , comparable to 68.1% in our study.

40 patients had IUGR new-borns in the research by Teena Nagar et al.[14] which was predicted by aberrant uterine artery Doppler in 25 instances with a sensitivity of 37.5%, 25%, and 50% for S/D ratio, RI and notch, respectively. It shares the same viewpoint as that of Irion et al, [15] North et al, and Bower et al[16] For S/D, RI and notch, the specificity was 93.48%, 94.56%, and 95.65%, respectively. Velauthar et al. [17] conducted a meta-analysis of 18 studies including 55,974 women and discovered that aberrant uterine artery Doppler had sensitivities of 26.4% and 15.4%, respectively, and specificities of 93.4% and 93.3% for predicting preeclampsia and foetal growth restriction. The maximum positive predictive value of the notch was 50%. Again, notch outperformed all other indicators as a forecast in this situation.

By measuring the mean uterine artery PI above the 95th percentile at 23 weeks of gestation, Lees et al. [18] showed that there is a substantial correlation between poor foetal development, placental abruption, PE, and foetal mortality. Its usage as a screening test would make it possible to identify patients who need careful monitoring and a suitable delivery plan and assess their particular risks.

In the same year, Papageorghiou et al [19] noted that only 41% of instances of PE and 16% of cases exacerbated by FGR were identified when mean uterine artery PI was above the 95th percentile (1.63) in the second trimester. The same cut-off was able to identify 93% of the PE patients and 56% of the FGR cases that required delivery before 32 weeks of gestation despite its low sensitivity.[19]

The utilisation of uterine arteries PI over the 90th percentile in the first trimester was only able to detect 47% of the instances of early-onset PE and 39.2% of the cases of early-onset FGR, with a false-positive rate of 7%, in a recent meta-analysis that included 18 studies and more than 55,000 pregnancies.

Conclusion

The presence of a high resistance index value greater than 0.58, systolic to diastolic (S/D) ratio greater than 2.6 and persistent uterine notching after 24-28 weeks are indicators of pregnancy induced hypertension, intrauterine growth retardation and adverse perinatal outcome. Sensitivity and specificity of Uterine S/D ratio greater than 2.6 and of resistance index greater than 0.58 were 73.6%, 58.1% and 68.1%, 46.42% respectively. The correlation between uterine notching and pregnancy-induced hypertension had a sensitivity of 88.8% and a specificity of 54.05%, respectively. Doppler velocimetry of the uterine artery is thus one of the best prenatal tools to identify the intrauterine growth retardation that may require additional antepartum surveillance and early obstetric intervention. Knowledge of Doppler blood flow abnormalities has allowed obstetricians to focus on these patients and thus reduce the incidence of perinatal morbidity and mortality.

References

1. Yu CK, Khouri O, Onwudiwe N, Spiliopoulos Y, Nicolaides KH. Prediction of pre-eclampsia

by uterine artery Doppler imaging: relationship to gestational age at delivery and small-for-gestational age. Ultrasound Obstet Gynecol 2008; 31(03):310-313.
2. North RA, Ferrier CL Long D, Townend K, Kincaid-Smith F. Uterine artery Doppler flow velocity waveforms in the second trimester for the prediction of pre-eclampsia and IUGR. Obstet Gynecol 1994; 83(3):378-63.
3. Schulman H, Weiner Z. Doppler ultrasound in pregnancy. In: Taylor KJW, Burns PN, Wells PNT, eds. Clinical applications of Doppler ultrasound. 2nd edn. Vol. 12. New York: Raven Press Ltd 1995:249-60.
4. Trudinger BJ, Cook CM, Thompson RS. Low dose aspirin therapy improves fetel weight in umbilical placental insufficiency. Am J Obstel Gynaecol 1988; 159(3):681-5.
5. Fleischer AC, Manning FA, Jeanty P, Romero R. Sonography in Obstetrics and Gynecology, Priniciples and Practice. 5th edn. Appleton & Lange 1995.
6. Fleisher A, Schulman H, Farmakides G, Bracero L, Grunfeld L, Rochelson B, et al. Uterine artery Doppler velocimetry in pregnant women with hypertension. Am J Obstet Gynecol 1986; 154(4):806-13.
7. Yu CK, Papageorghiou AT, Boli A, Cacho AM, Nicolaides KH. Screening for pre-eclampsia and fetal growth restriction in twin pregnancies at 23 weeks of gestation by transvaginal uterine artery Doppler. Ultrasound Obstet Gynecol 2002; 20(6):535-40.
8. Rezende-Filho J, Castro P, Leite SP, Montenegro CA, de Almeida Lima MD. Pre-eclampsia: An overview in placentation, endothelial dysfunction and flow-mediated vasodilation. The Ultrasound Review of Obstetrics and Gynecology. 2005; 5(4):242-53.
9. Ott WJ. Diagnosis of intrauterine growth restriction: Comparison of ultrasound parameters. Am J Perinatol 2002; 19(3):133-8.
10. Vyas S, Nicolaides KH, Bower S, Campbell S. Middle cerebral artery flow velocity waveforms in fetal hypoxaemia. J. Obstet Gynecol 1990; 97(9):797-803.
11. Madazli R, Uludağ S, Ocak V. Doppler assessment of umbilical artery, thoracic aorta and middle cerebral artery in the management of pregnancies with growth restriction. Acta Obstet Gynecol Scand 2001; 80(8):702-7.
12. Campbell S, Diaz-Recasens J, Pearce JM, Diaz-Recasens J, Cohen-Overbeek TE, Willson K, et al. New Doppler technique for assessing uteroplacental blood flow. Lancet 1983; 321(8326):675-7.
13. Harrington K, Carpenter RG, Nguyen M, Campbell S. Changes observed in Doppler studies of the fetal circulation in pregnancies complicated by pre-eclampsia or the delivery of small for gestational age baby. I cross sectional analysis. Ultrasound Obstet Gynecol 1995; 6(1):19-28.
14. Nagar T, Sharma D, Choudhary M, Khoiwal S, Nagar RP, Pandita A. The role of uterine and umbilical arterial Doppler in high-risk pregnancy: a prospective observational study from India. Clinical Medicine Insights: Reproductive Health 2015; 9: CMRH-S24048.
15. Irion O, Massé J, Forest JC, Moutquin JM. Prediction of pre-eclampsia, low birth weight 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.
16. Bower S, Bewly S, Campbell S. Improved prediction of pre-eclampsia by two-stage screening of uterine arteries using the early diastolic notch and color. Doppler Imaging 1993;82(1):78-83.
17. Velauthar L, Plana MN, Kalidindi M, Zamora J, Thilaganathan B, Illanes SE, et al. First trimester uterine artery Doppler and adverse pregnancy outcome: a meta-analysis involving 55,974 women. Ultrasound Obstet Gyanecol 2014; 43(5):500-7.
18. Lees C, Parra M, Missfelder-Lobos H, Morgans A, Fletcher O, Nicolaides KH. Individualized risk assessment for adverse pregnancy outcome by uterine artery Doppler at 23 weeks. Obstet Gynecol 2001; 98(03):369-73.
19. Papageorghiou AT, Yu CK, Bindra R, Pandis G, Nicolaides KH, et al. Multicenter screening for pre-eclampsia and fetal growth restriction by transvaginal uterine artery Doppler at 23 weeks of gestation. Ultrasound Obstet Gynecol 2001; 18(05):441-9.