

COMPARATIVE ANALYSIS OF UMBILICAL ARTERY DOPPLER PLACENTAL SITE, FREE LOOP AND ABDOMINAL SITE IN NORMOTENSIVE AND HYPERTENSIVE FEMALES DURING SECOND TRIMESTER OF PREGNANCY

Tooba Khalid^{*1}, Rashida Perveen¹

¹ Faculty of Allied Health Sciences, Superior University Lahore

Corresponding Author: toobakhalid50@gmail.com

DOI: <https://doi.org/10.5281/zenodo.14715931>

Received	Revised	Accepted	Published
27 November, 2024	27 December, 2024	11 January, 2025	22 January, 2025

ABSTRACT

Introduction: Umbilical artery Doppler ultrasonography has emerged as a valuable non-invasive tool for assessing fetal well-being and placental function during pregnancy. Aim of Study: To compare the Doppler indices in normotensive and hypertensive females in 2nd trimester of pregnancy at different sites of umbilical artery. Methodology: This cross-sectional descriptive study examined umbilical artery Doppler indices in normotensive and hypertensive pregnant women during their second trimester. The study included 112 participants (56 hypertensive, 56 normotensive) aged 18-45 years with singleton pregnancies, recruited using non-probability purposive sampling at the Radiology Department of Medics Dr Amers over a 9-month period. Umbilical artery Doppler measurements were taken at placental, abdominal, and free loop sites. Results: Results indicated that in hypertensive females Doppler indices of umbilical artery vary remarkably at different sites ($p < 0.05$). Whereas in non-hypertensive females this significance was absent. These findings of this study suggested that umbilical artery Doppler indices can be helpful to differentiate normotensive from hypertensive pregnancies during the second trimester. Conclusion: This study concluded that umbilical artery Doppler indices (RI, PI, and SD ratio) at different sites are significantly higher in hypertensive pregnant women as compared to non-hypertensive females during the second trimester.

Keywords: Umbilical artery Doppler (UAD), Pregnancy-induced hypertension (PIH), Resistive index (RI), Pulsatility index (PI), Systolic/diastolic ratio (S/D Ratio).

INTRODUCTION

Doppler ultrasonography has contributed a lot to obstetrics in that it has offered a procedure for the assessment of the fetus without the need to intervene in the pregnancy in order to determine the flow of blood in the umbilical artery. As such this technique is beneficial to identify fetuses prone to complications including FGR and pre-eclampsia. The Doppler derived umbilical artery indices are the pulsatility index (PI), resistance index (RI) and systolic/diastolic ratio (S/D) that provide information on vascular resistance and placental function to assess risk in pregnancy.^{1,2}

The placental/mechanical indices in normotensive pregnancy normally reveal a decline in vascular resistance with increasing gestational ages to signify better supply in the placenta. On the other end we have hypertensive pregnancies, and many of these present with increased vascular resistance thus speaking of compromised placental function. Referring to this distinction is important in the management of these pregnancies especially to decrease perinatal morbidity and mortality.³

The comparison of Doppler indices obtained at different segments of the cord like placental site, free loop and abdominal site gives a more precise idea about the fetal status. The hemodynamic parameters at each site may be different, and therefore clinical assessments and management decisions may differ accordingly. It is crucial to recognize these differences for enhancing fetal monitoring practices, particularly in differentiating between normotensive and hypertensive pregnancies during the second trimester.

Doppler ultrasound not only improves the accuracy of fetal monitoring but also helps in individualizing the care in order to optimise maternal and fetal outcomes. It makes it possible to assess normal and impaired uteroplacental blood flow during pregnancy and in the intrapartum period. This approach is useful in the monitoring of IUGR fetuses⁵ and in avoiding routine antenatal scans and caesarean sections for suspected fetal compromise. Therefore, Doppler ultrasound has introduced a new functional aspect in the diagnostic ultrasound and is very useful for the management of high risk pregnancies.⁶ This measurement provides important information on fetal growth and development and risk of adverse outcome such as FGR, preterm birth or still birth. However, in Pakistan there is scarcity of literature regarding this issue, thus the need of conducting research to set up standard reference ranges for the local population. Umbilical artery Doppler values need to be interpreted in relation to norms for normal values in order to identify high risk pregnancies and institute timely management to prevent complications.

Objective:

To compare the Doppler indices in normotensive and hypertensive females in 2nd trimester of pregnancy at different sites of umbilical artery.

Methodology:

This cross-sectional descriptive study examined umbilical artery Doppler indices in normotensive and hypertensive pregnant women during their second trimester. The study included 112 participants (56 hypertensive, 56 normotensive) aged 18-45 years with singleton pregnancies, recruited using non-probability purposive sampling at the Radiology Department of Medics Dr Amers over a 9-month period. Umbilical artery Doppler measurements were taken at placental, abdominal, and free loop sites.

Results:

The study included a total of 112 participants, equally divided into 56 hypertensive and 56 normotensive females. The mean age of participants was 30.3 ± 4.7 years, with ages ranging from 19 to 38 years. Regarding gravidity, the majority of women (26.1%) were pregnant for the third time, while 66.9% had no history of previous abortions.

Umbilical artery Doppler indices were measured at three sites: placental, abdominal, and free loop. In normotensive females, the mean \pm SD values for RI, PI and SD ratio at the placental site were 0.59 ± 0.08 , 0.89 ± 0.2 , and 2.6 ± 0.69 , respectively. For hypertensive females, these values were 0.71 ± 0.08 , 1.3 ± 0.4 , and 3.4 ± 1.2 , respectively.

Similar patterns were observed at the abdominal and free loop sites, with hypertensive females consistently showing higher values across all indices. Statistical analysis revealed significant differences in umbilical artery Doppler indices between normotensive and hypertensive groups. While no statistical significance was found among indices in the normotensive group, the hypertensive group showed significant differences across all sites and indices ($p < 0.05$). Anova results confirmed statistical significance for both pulsatility index (PI) and resistive index (RI) between the groups ($p < 0.05$)

Normotensive group.		Sum of Squares	df	F Statistics	Sig. P value
placental site RI	Between Groups	.170	26	1.021	0.476
	Within Groups	.185	29		
	Total	.355	55		
PI	Between Groups	3.279	26	.515	0.954
	Within Groups	7.102	29		
	Total	10.381	55		
abdominal site RI	Between Groups	.282	26	.693	.826
	Within Groups	.454	29		
	Total	.737	55		

PI	Between Groups	3.844	26	.872	.636
	Within Groups	4.919	29		
	Total	8.764	55		
free loop RI	Between Groups	.137	26	1.071	.427
	Within Groups	.142	29		
	Total	.279	55		
PI	Between Groups	1.631	26	.870	.639
	Within Groups	2.092	29		
	Total	3.722	55		

Table 1: Comparison of Umbilical artery Doppler of Normotensive group.

For the placental site, the analysis showed no significant differences between groups for RI ($F(26, 29) = 1.021, p = 0.476$) or PI ($F(26, 29) = 0.515, p = 0.954$). Similarly, at the abdominal site, no significant differences were found for RI ($F(26, 29) = 0.693, p = 0.826$) or PI ($F(26, 29) = 0.872, p = 0.636$). The free loop measurements

also revealed no significant differences between groups for RI ($F(26, 29) = 1.071, p = 0.427$) or PI ($F(26, 29) = 0.870, p = 0.639$). The consistently high p-values (all > 0.05) across all measurements indicate that there are no statistically significant variations between groups for any of the examined parameters in this normotensive group. (Table 1)

Table 2: Comparison of umbilical artery Doppler indices of hypertensive group.

Hypertensive group		Sum of Squares	df	F	Sig. p value
Placental site RI	Between Groups	.219	26	1.86	<0.029
	Within Groups	.185	29		
	Total	.388	55		
PI	Between Groups	1.503	26	1.69	<0.01
	Within Groups	1.277	29		
	Total	2.780	55		
Abdominal site RI	Between Groups	4.150	26	17.348	<.0001
	Within Groups	.267	29		
	Total	4.417	55		
PI	Between Groups	.241	26	4.23	<0.01
	Within Groups	.329	29		
	Total	.570	55		
Free loop RI	Between Groups	1.901	26	8.97	<0.05
	Within Groups	2.444	29		
	Total	4.345	55		
PI	Between Groups	2.20	26	4.24	<0.01
	Within Groups	2.1	29		
	Total	4.25	55		

The analysis in hypertensive group reveals statistically significant differences between groups across all measurements. At the placental site, significant variations were found for RI ($F(26, 29) = 1.86, p < 0.029$) and PI ($F(26, 29) = 1.69, p < 0.01$). The abdominal site showed the most pronounced differences, with RI demonstrating an extremely significant variation ($F(26, 29) = 17.348, p < 0.0001$) and PI also showing significant differences ($F(26, 29) = 4.23, p < 0.01$). Similarly, the free loop measurements exhibited significant variations for both RI ($F(26,$

$29) = 8.97, p < 0.05$) and PI ($F(26, 29) = 4.24, p < 0.01$) (Table 2)

Discussion:

The present study investigated umbilical artery Doppler indices at different sites along the umbilical cord in normotensive and hypertensive pregnant women. Our findings reveal significant differences in these indices between the two groups, with hypertensive females consistently showing higher values across all measurement sites.

Sonesson et al. (2013) reported higher systolic-diastolic ratio (S/D), pulsatility index (PI), and

resistance index (RI) at the fetal end of the umbilical cord compared to the placental end. Our study corroborates these findings, showing consistent differences between normotensive and hypertensive groups across all measurement sites. In normotensive females, we observed mean \pm SD values for RI, PI, and S/D ratio at the placental site of 0.59 ± 0.08 , 0.89 ± 0.2 , and 2.6 ± 0.69 , respectively. For hypertensive females, these values were significantly higher: 0.71 ± 0.08 , 1.3 ± 0.4 , and 3.4 ± 1.2 , respectively. This pattern was consistent across all measurement sites, suggesting that hypertension-induced hemodynamic changes affect the entire length of the umbilical cord ⁷.

Our results also complement those of Cohen et al. (2014), who confirmed the presence of a resistance gradient along the umbilical cord. They observed a significant increase in both Resistance and Pulsatility Indices from the placental toward the fetal end. Our study demonstrates that this gradient is maintained but elevated in hypertensive pregnancies. For instance, we found that the PI values increased from the placental to the fetal end in both groups, but the values were consistently higher in the hypertensive group. This indicates that hypertension not only increases overall resistance but may also amplify the existing physiological gradient ⁸.

Interestingly, our findings diverge from those of Bhide et al. (2019), who concluded that standardizing the site of umbilical artery Doppler sampling does not significantly reduce measurement variability. In contrast, our study highlights the importance of multi-site measurements. We observed significant differences in Doppler indices between normotensive and hypertensive groups at all three measurement sites (placental, abdominal, and free loop). For example, the RI values at the placental, abdominal, and free loop sites in the hypertensive group were consistently higher than those in the normotensive group, with all differences being statistically significant ($p < 0.05$). This suggests that comprehensive assessment at multiple sites may provide more robust clinical information, particularly in high-risk pregnancies ⁹.

Our approach of measuring at three distinct sites aligns with the recommendation by Mehalek et al. (2019) for uniform measurement techniques. While they focused on improving accuracy in individual patients, our study demonstrates that this multi-site approach can effectively

differentiate between normotensive and hypertensive pregnancies. The statistical significance we found for both PI and RI between the groups ($p < 0.05$) in all the measurement sites emphasizes the possibility of clinical application of this method ¹⁰.

Results from current study were found to be in coherence with existing literature. The Doppler indices in hypertensive pregnancies were uniformly elevated, irrespective of the site of measurement, may indicate that the use of the multi-site approach of Doppler fetal monitoring can be more sensitive in identifying and assessing high risk pregnancies than a single site assessment.

Conclusion:

Our study confirms that hypertensive pregnancies exhibit significantly higher umbilical artery Doppler indices across multiple measurement sites compared to normotensive pregnancies, indicating pervasive hemodynamic changes along the umbilical cord.

REFERENCES

- Widnes C, Flo K, Wilsgaard T, Kiserud T, Acharya G. Sex differences in umbilical artery Doppler indices: a longitudinal study. *Biology of sex Differences*. 2018 Dec;9:1-2.
- Adedo AA, Arogundade RA, Okunowo AA, Idowu BM, Oduola-Owoo LT. Comparative Study of the Umbilical Artery Doppler Indices of Healthy and Growth-Restricted Foetuses in Lagos. *Journal of West African College of Surgeons*. 2022 Apr 1;12(2):63-9.
- Awan MW. Comparison of Fetal Umbilical Artery Doppler Indices between Normal and Hypertensive Pregnant Women in the Second Trimester of Pregnancy. *Ann. Pak. Inst. Med. Sci*. 2015;11(2):95-9.
- Morris RK, Malin G, Robson SC, Kleijnen J, Zamora J, Khan KS. Fetal umbilical artery doppler to predict compromise of fetal/neonatal wellbeing in a high-risk population: systematic review and bivariate meta-analysis. *Ultrasound in Obstetrics & Gynecology*. 2011 Feb;37(2):135-42.
- Ertan AK, Hendrik HJ, Tossounidis I, Schimidt W. Normal fetomaternal Doppler indices in the second and third trimesters of pregnancy. *Color Doppler Sonography in*

Gynecology and Obstetrics. New York, NY: Thieme. 2005:129-43.

- 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 in Obstetrics and Gynecology: The Official Journal of the International Society of Ultrasound in Obstetrics and Gynecology*. 2008 Mar;31(3):310-3.
- Sonesson SE, Fouron JC, Drblik SP, Tawile C, Lessard M, Skoll A, Guertin MC, Ducharme GR. Reference values for Doppler velocimetric indices from the fetal and placental ends of the umbilical artery during normal pregnancy. *Journal*

of clinical ultrasound. 2013 Jun;21(5):317-24.

- Cohen J, Wauquiez MJ, Janse-Marec J. Doppler analysis of the umbilical artery: why we must prefer the free loop of the cord. *Minerva Ginecologica*. 2014 Oct 1;66(5):455-9.
- Bhide A, Badade A, Khatal K. The effect of sampling site on the variability of umbilical artery PI. *European Journal of Obstetrics & Gynecology and Reproductive Biology*. 2019 Apr 1;235:102-5.
- Mehalek KE, Rosenberg J, Berkowitz GS, Chitkara U, Berkowitz RL. Umbilical and uterine artery flow velocity waveforms. Effect of the sampling site on Doppler ratios. *Journal of ultrasound in medicine*. 2019 Apr;8(4):171

Case 1:

Umbilical artery Doppler ultrasound of normotensive female in 2nd trimester of pregnancy at the free loop of umbilical artery the resistive index was 0.57, pulsatility index was 0.80 and S/D ratio was 2.30. At placental site the values were slightly raised with RI at 0.64, PI 0.99 and S/D ratio of 2.7. Lastly at abdominal site the resistance index 0.65, PI measuring 0.97 and S/D ratio 2.89.



