

COMPARISON OF OPTIC NERVE SHEATH DIAMETER AND UMBILICAL ARTERY INDICES MEASURED ON ULTRASOUND AMONG HYPERTENSIVE AND CONTROLS IN THIRD TRIMESTER PREGNANCIES

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Abstract

Introduction: Hypertensive pregnancies related to high rates of maternal as well as fetal complications. It increases the prevalence of metabolic, cardiac and cerebrovascular complications in earlier age women. This study assess effect of maternal hypertension upon fetal growth and maternal cerebrovascular health by sonography

Methodology: All one hundred twenty patients in this cross-sectional study categorized as controls and hypertensive pregnant women groups. Hypertensive group further divided into three categories as raised, stage I and stage II hypertension. Fetus gestational age, doppler indices of umbilical artery and maternal optic nerve sheath diameter measured in all participants.

Results: Mean patient age was 28 ± 4.7 with maximum numbers of participants were of 33 years old and minimum numbers were from 22-24 age group. Sixty patients with normal blood pressure shows normal umbilical artery diastolic flow while one pregnancy shows decrease diastolic flow, 24 have absent diastolic flow and 13 have reversed diastolic flow. Umbilical artery RI value was also above 0.7 in eight pregnancies with raised blood pressure, twenty-one pregnancies at stage I hypertension and in all stage II hypertensive pregnancies. ONSD value above normal range $>0.5\text{cm}$ mainly observed in pregnancies with hypertension. Out of 45 patients with increase ONSD, 3 were from normal blood pressure, 12 from elevated BP, 21 from stage I and 9 from stage II hypertension category. Significant difference visualized among hypertensive and non-hypertensive ONSD for both right and left eyes with $p\text{-values} < 0.001$. There is also

positive correlation between umbilical artery resistivity index and maternal optic nerve sheath diameter measured in left and right eyes.

Conclusion: Umbilical artery resistivity index and maternal optic nerve sheath diameter was higher in hypertensive pregnancies in comparison to normotensive pregnancies during third trimester.

Introduction

During pregnancy hypertension is most reported medical comorbidity, and related disorders to this comorbidity in pregnancy are linked to a high level of risks profile for adverse consequences among mother and fetus (1, 2). These consequences further burdened medical sector as the incidence of pregnancy complications due to hypertension increased globally from 16.30 to 18.08 million, with an overall enhance rate of 10.92 % in time duration of 1990-2019 (3). High blood pressure complications during Pregnancy like preeclampsia and high-risk eclampsia related to alarming outcomes like intrauterine growth restriction and preterm birth or low birth weight (4). Many research observations reported for increasing trends of metabolic, cardiac, renal and cerebrovascular complications during pregnancy for young age mothers due to Hypertensive disorders of pregnancy (HDP) which complicate overall 5-10 percent pregnancies. It resulted in more complications including death of mother and child or both, co-morbidities, particularly in those with history of severe hemolysis, preeclampsia, elevated hepatic enzymes, eclampsia and reduced low platelets situations (5).

Hypertensive pregnancies related to severe fetal outcomes like perinatal deaths and stillbirths in low weight fetus before thirty-two gestational weeks. Preeclampsia increases the risk of intrauterine growth retardation and still birth as well as it may result as decrease birth weight. (6) Examination of Umbilical artery by doppler is a significant noninvasive approach to evaluate fetal outcomes due to maternal hypertension. Decrease peak systolic velocity and ED volume, along with high S/D, R-index and P-index reported in patients who suffered due to preeclampsia and gestational hypertension (7). Irregular waveform of umbilical artery obtained by doppler is a predictor of rapid decrease rate in growth as compare to actual expected growth rate while

low gestational age fetus along with regular doppler waveforms also shows high percentages of newborn ICU admissions (8). Gestational hypertension also adversely affects maternal health. Hemorrhage and high blood pressure complications are foremost severe factors to high mortality rate of pregnant women in health sector of developing populations. As per WHO statistics, during pregnancy, hemorrhage was found out one of the prominent contributors to death among mothers in Asians and Africa regions (9). Moreover, hypertension existed during pregnancy can disturb several earlier existing neurologic disorders, most likely epilepsy, any brain area tumors and brain internal bleeding in cerebral aneurysm conditions or AV malformations. These intracranial disorders observed in pregnancy weeks make patients to be sit at a high risk of intracranial hypertension (IHT) (10). Apart from this, temporal region headache, prolonged seizures of epilepsy, mental tiredness, insomnia and migraine complications from birth time to years also linked to the during gestation high blood pressure and its complications like preeclampsia and eclampsia (11). This can be related to intracranial hypertension which appears to show symptoms during the first and second two trimesters of gestation with typical findings (12). Early evaluation of intracranial hypertension during pregnancy is crucial to manage adverse maternal cerebrovascular effects of gestational hypertension. Measurement of optic nerve sheath diameter (ONSD) is one of the potential promising methods for assessing the increased risk of developing cerebral edema (13). As there is communication between brain ventricular spaces and sheath subarachnoid space, monitoring fluctuations in the optical nerve sheath's width therefore offers vital information about changes in intracranial pressure (14). Numerous studies have uncovered an immediate correlation regarding

ONSD measurement and pressure in the intracranial cavity. High ONSD is a strong predictor of elevated intracranial pressure (15). Real-time sonographic imaging is non-radiation imaging with low discomfort and high interobserver reliability in ONSD measurement. (16)

A major purpose in this current study was to assess impact of hypertension on fetus and mother simultaneously by sonographic evaluation of umbilical artery and maternal optic nerve sheath diameter in hypertensive pregnancies and compare this with healthy 3rd trimester pregnancies. It will improve clinician's perspective to monitor and manage maternal hypertension and identify women and fetus at high risk of cerebrovascular disease and also mitigate the risk of disease-related complications.

Objective

To assess effect of maternal hypertension upon fetal growth and maternal cerebrovascular health compare to the healthy 3rd trimester pregnancies by sonographic predictor

Material and Methods

Clinical Settings: Study was completed in Rehmat General Hospital, Rahim Yar Khan

Duration of Study: After departmental approval of synopsis, this study completed in four months

Sample Size: Sample size was 120 patients in 3rd trimester pregnancy, divided into two groups, 60 for normotensive and 60 for hypertensive group

Selection Criteria

Inclusion Criteria

- Pregnancies in third trimester were included.
- Age group of >18 years were included.
- Singleton pregnancy
- Women with chronic hypertension and gestational hypertension both were included

Exclusion Criteria

- Pregnancies with congenital malformations were excluded.
- Women with any clinical history of traumatic brain injury were excluded
- Women with any neurological disorders were excluded.
- Women with eye infections or itching in eyes

Research Design: It was a cross sectional, analytical study

Sampling Technique: This study incorporates simple random sampling technique

Data Collection Procedure

Study subjects were accepted for this study keeping in mind the inclusion and exclusion criteria. Written informed consent was obtained initially and all possible benefits and expected risks also explained to participants. Basic demographic and clinical information about risk factors and medical history about blood pressure were obtained in detail from patients and noted down on a pre designed data collection sheet. Total 120 patients examined in two groups labeled as normal and hypertensive. After estimation of fetal gestational age by fetal biometry, umbilical artery doppler performed by 3-5 MHz convex transducer. After that, maternal optic nerve sheath diameters, sonographic examination was performed by linear transducer at 10-12 MHz. Patient was positioned as supine with head position raised up to 20-30°. Transducer positioned on face temporal region (on eyelid) where gel was already applied, to decrease pressure and friction on the eye. When scan shows the maximal eyeball transverse diameter, all measurements were taken in centimeter scale. Measurement was taken at 0.3 cm behind the eye orbit or vitreous chamber ball. Both left and right sides optic nerve diameter examined three times and the mean value calculated. All sonographic findings entered in predesigned proforma for further statistical analysis

Data Analysis

Data entry management and evaluation done by using data analysis software SPSS version

25.0. Basic statistics about data description was calculated (including mean $\pm$ SD, maximum as well as minimum values) and frequencies compare by cross tabulation. Continuous variables compared by application of independent sample t-test. Between umbilical artery doppler resistivity index and maternal optic nerve sheath diameter correlation was determined by Pearson Correlation, in both eyes. P value of < 0.05 assumed acceptable statistically.

Results

In study sample size was 120 and data collected from third trimester pregnancies in patients age above 18 years. All participants divided into two groups, with 60 patients belongs to normotensive and 60 patients included in hypertensive group at different stages randomly. Mean patient age was 28 ± 4.7 years with minimum age at 20 years and maximum at 38 years among total 120 patients. Maximum Numbers of Participants 13 were of Age 33 Years while Minimum Numbers of Participants 4 were in 20-22 Years of Age Range.

		GALMP	GAUSG
N	Valid	120	120
	Missing	0	0
Mean		33.70	32.52
Std. Deviation		2.41	2.51
Minimum		29.00	27.00
Maximum		38.00	38.00

Table 1 shows mean gestational age by LMP was 33 ± 2.4 weeks while by sonography it was 32 ± 2.5 weeks Patients categorized on basis of their blood pressure into normal, elevated, stage I and Stage II hypertension groups. Out of 120 total patients, 60 were having no history of raised blood pressure while 29 were having elevated pressure of blood, 22 categorized as stage I of hypertension and 9 were at stage II of hypertension

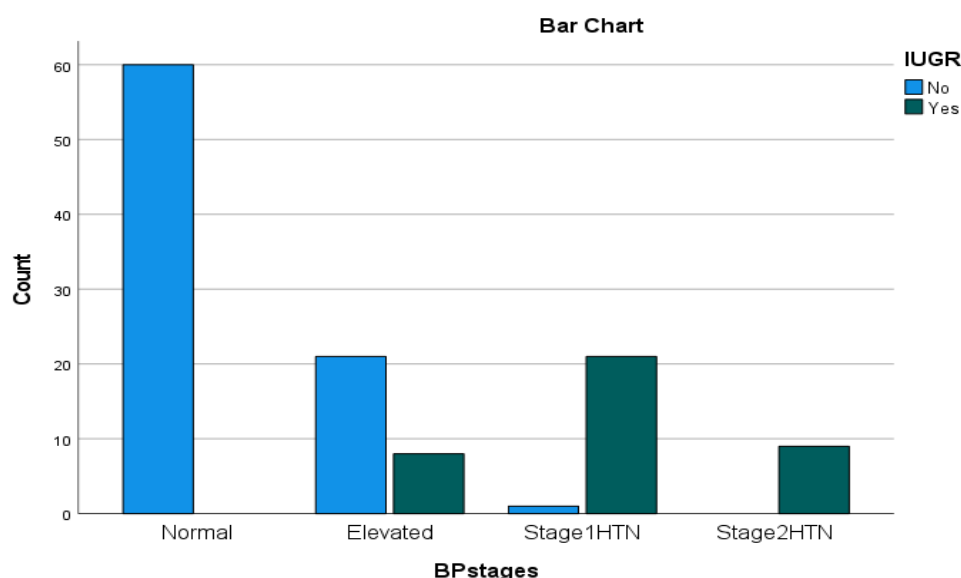


Fig 1 Shows frequency distribution of IUGR pregnancies among normotensive and hypertension stages patients. Out of 120 third

trimester pregnancies, 38 were IUGR. No IUGR pregnancy found among 60 normal blood pressure patients while out of 38 IUGR

pregnancies 8 having elevated BP, 21 having stage 1 hypertension and all 9 pregnancies with

stage 2 of hypertension had IUGR at the time of scan

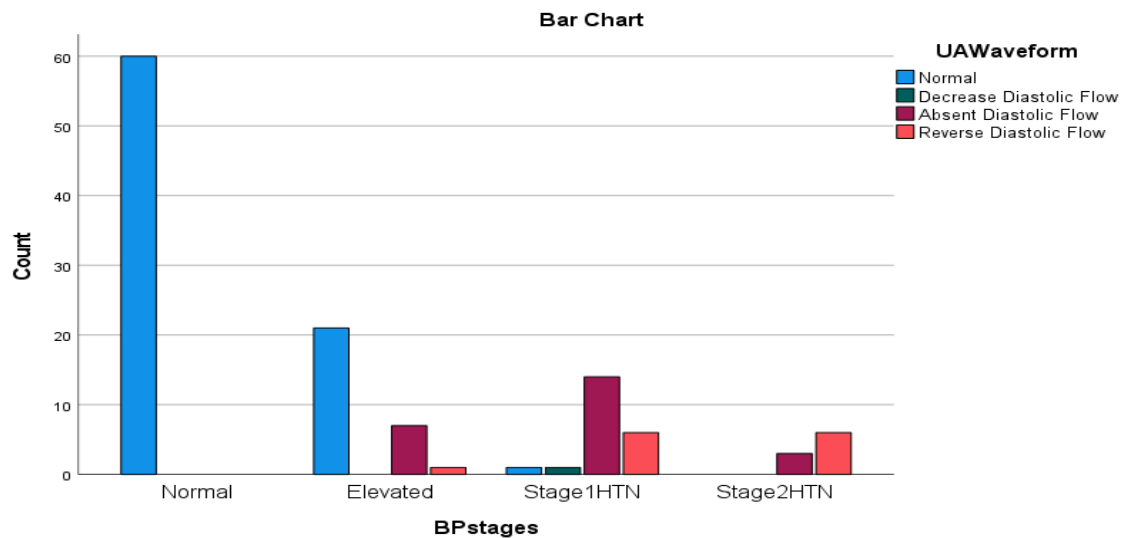


Fig 2 Shows Umbilical Artery Waveform Patterns among Normotensive and Hypertension Stages

BP stages * UARI Crosstabulation				
Count				
		UARI		Total
		<0.7	>0.7	
BP stages	Normal	60	0	60
	Elevated	21	8	29
	Stage1HTN	1	21	22
	Stage2HTN	0	9	9
Total		82	38	120

Table 2 shows umbilical artery RI value was <0.7 in normal blood pressure pregnancies while RI value was >0.7 in 8 pregnancies with elevated stage of blood pressure, 21 pregnancies with stage I hypertension while it was >0.7 also in all stage II hypertensive pregnancies.

Larger mean values of umbilical artery RI in hypertensive groups. Average mean of RI value in normal blood pressure patient's umbilical artery was 0.60 while in hypertensive group it

was 0.71. There was significance difference for umbilical artery RI mean values in normal and hypertensive patients by independent sample t-test with p value <0.005. Similarly, there was significance difference for ONSD of right and left eye mean values in normal and hypertensive patients by independent sample t-test with p value <0.005. Pearson correlation shows positive correlation between umbilical artery and both right and left optic nerve sheath diameters.

BP stages * ONSD Crosstabulation			
Count			
		ONSD	
		<0.5cm	>0.5cm
		Total	

BP stages	Normal	57	3	60
	Elevated	17	12	29
	Stage1HTN	1	21	22
	Stage2HTN	0	9	9
Total		75	45	120

Table 3 shows among 120 patients in this study, 45 have increased ONSD while 75 has less than 0.5cm ONSD in average for both eyes. Out of 45 patients with increase ONSD,

3 were from normal blood pressure, 12 from elevated BP, 21 from Stage 1 hypertension and 9 were from stage 2 hypertension category.

Correlations			
		UA RI value	ONSDR
UA RI value	Pearson Correlation	1	.753
	Sig. (2-tailed)		.000
	N	120	120
ONSDR	Pearson Correlation	.753	1
	Sig. (2-tailed)	.000	
	N	120	120

Table 4 shows good positive association between the umbilical artery RI value and ONSD of right eye. The Pearson's correlation coefficient was $r=0.753$ ($p < 0.05$)

Correlations			
		UA RI value	ONSDL
UA RI value	Pearson Correlation	1	.514
	Sig. (2-tailed)		.000
	N	120	120
ONSDL	Pearson Correlation	.514	1
	Sig. (2-tailed)	.000	
	N	120	120

Table 5 shows good positive association between the umbilical artery RI value and ONSD of left eye. The Pearson's correlation coefficient was $r=0.514$ ($p < 0.05$)

Discussion

As per calculated sample size, total 120 patients participated in study, between age 20-38 years and according to preset inclusion and exclusion criteria. Mean values of gestational age in weeks measured by LMP was slightly higher than gestational age by ultrasound as data analysis revealed mean gestational age by LMP was 33 ± 2.4 weeks while by sonography it was decrease to 32 ± 2.5 weeks. All 38 IUGR pregnancies were from hypertension group at

different stages of high blood pressure. This shows a hypertension severity as major contributor to intrauterine growth retardation in 3rd trimester of pregnancy. Veerbeek JH et al, 2014 also reported that maternal hypertension is associated with characteristic inflammatory changes in placenta and umbilical artery absent/reverse end diastolic flow with signs of chronic hypoxia which are highly associated with intrauterine growth retardation (17). Mohammad N et al in 2018, also mentioned in their study that along with many other maternal factors like young early age, low gain in weight during gestation, multiple abortion clinical history, primigravida status, gestational metabolic disorders like

gestational diabetes and pregnancy induced hypertension is one of the major contributors to IUGR pregnancies (18).

Umbilical artery waveform pattern is an important predictor of effects of maternal hypertension on fetus growth process because increasing resistance in umbilical artery cause hypoxia and it appear as changes in diastolic flow. Correlation of waveforms patterns of umbilical artery patterns to stages of hypertension revealed severity of abnormality in diastolic flow increase with increasing levels of maternal hypertension. All these noticeable changes in diastolic wave appear within hypertensive patients and shows maternal hypertension profound effect upon fetus blood supply which resulted as adverse fetal outcomes. Trudinger and Cook, also found in their study high blood pressure and proteinuria during gestation induce placental lesions and, in these pregnancies, abnormally appearing waveforms of umbilical artery velocity over time are positively correlated to serious fetal outcomes (19). Along with umbilical artery (UA) waveform patterns, doppler indices of UA also shows increase values for hypertensive pregnancies and it is correlated with IUGR and other adverse fetal outcomes. Statistical analysis shows significance difference between normotensive and hypertensive groups UA RI values with p-values < 0.001. Few researchers work also presented umbilical artery doppler indices significance in hypertensive pregnancies as a predictor for adverse fetal growth. Lin H et al, 2025, presented that in hypertensive pregnancies, a major doppler indices resistivity index to flow of blood in umbilical arterial supply reveal a high sensitivity level for prediction of oxygen deficiency to fetus and resulted slow growth, meanwhile another doppler indices pulsatility index shows good level of specificity for fetus growth delay during gestation. (20). Adekanmi AJ study in 2019, observed particularly lower values of arterial flow peak velocities at end systole in uterus and umbilical arteries in addition to low end diastolic velocity but higher values of resistivity index (RI), pulsatility index (PI) and ratio of S/D in pregnant patients that suffered due to pre-eclampsia with maternal hypertension (21).

Hypertension during pregnancy is proved to be a most important complication which resulted as several effects both for mother and fetus more prominently in maternal cerebrovascular health. Miller EC, study in 2022 shows major cause of high stroke incidence in pregnant women is high chronic blood pressure, hypertension newly onset in pregnancy and proteinuria disorders in addition to migraine (25). Hypertension may lead to changes in intracranial pressure (ICP) which is highly crucial for maternal cerebral health, with consequences as multiple various neurological disorders. Researchers like Colombari E et al in 2025, evaluated effect of hypertension on blood brain barriers and find out hypertension significantly disrupts the intricate dynamics of intracranial pressure regulation, contributing to a cascade of severe cerebrovascular and neurological consequences (26)

This study results shows, that cases of ONSD value above a normal range >0.5cm mainly observed in pregnancies with hypertension. Average mean value of diameter of right optic nerve sheath in hypertensive was 0.54cm while for diameter of left optic nerve sheath it was 0.54cm for hypertensive mothers. Singh SK et al, in 2019 statistically proved significant difference ($p < 0.05$) in ONSD when analyzed among hypertension induced complicated pregnancies groups and control group. Mean OSND level for preeclampsia and eclampsia pregnancy in pregnancy induced hypertension patients were 0.56cm and 0.58 cm, respectively, while for normotensive, ONSD at 0.47 cm noted (27). Da Mota MF study results in 2024, concluded that overall comparison between the all groups (control and hypertensive complication subgroups) showed insignificant variance in the average values of ONSD ($p = 0.056$). However, ONSD diameters increase values found in eclamptic pregnancies in contrast to control and it was significant ($p = 0.003$) (28). Increase ONSD is significantly related to neurological disorder in women. Khalifa AF et al in 2026, work shows, that during pregnancy third trimester, the average of high values of ONSD in sample group with neurological complications remained at 6.55 ± 0.28 mm but it was 5.60 ± 0.21 mm in sample group without neurological complications

with $P = 0.001$ (29). After assessment of these maternal and fetal parameters to assess effect of hypertension during pregnancy, in this study we find our correlation between umbilical artery RI value and sheath diameter for both optic nerve sheath in both right and left eyes. Pearson correlation analysis reveals a positive linear correlation among the umbilical artery RI value and ONSD of right and left eyes with Pearson coefficient of $r=0.753$ ($p < 0.05$) and for left eye ONSD and RI, Pearson coefficient was $r=0.514$ ($p < 0.05$). Final finding strongly proposes that scanning of hypertensive pregnancies should also focus upon optic nerve sheath diameter measurements in pregnancy women along with doppler based assessment of umbilical artery.

CONCLUSIONS

Umbilical artery doppler resistivity index and maternal optic nerve sheath diameter are significantly high in hypertensive patients than normal blood pressure pregnancies. There is also positive correlation between umbilical artery resistivity index and maternal optic nerve sheath diameter for both left and right eyes. It is suggesting that maternal optic nerve sheath diameter could be a potential marker to assess adverse effects on maternal cerebrovascular system in hypertensive pregnancies as it is a proved indicator for elevated intracranial pressure. Sonography advantages of easily bed side availability, being noninvasive and cost affording medical facility for monitoring both of these parameters simultaneously during scan.

Declaration of Conflicting Interest:

The authors declare no conflict of interest regarding the publication of this research work.

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