Original Article

Predicting Intrauterine Growth Restriction in Hypertensive Pregnancy: Cerebroplacental Ratio & Umbilical Artery Waveform

Samiya Iqbal Sahibzada[1,2]*, Iffat Naheed[1]

[1]Lady Aitchison Hospital, King Edward Medical University, Lahore, Pakistan

[2]Primary and Secondary Health Department, Govt of Punjab, Lahore, Pakistan

*Corresponding Author

Samiya Iqbal Sahibzada
samiyasahibzaada89@gmail.com

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Abstract

Objective: To evaluate the diagnostic accuracy of the cerebroplacental ratio compared to the umbilical artery waveform in predicting adverse fetal outcomes, specifically intrauterine growth restriction (IUGR), in hypertensive pregnancies.

Methodology: This descriptive cross-sectional study of six months' duration from August 2018 to February 2019 was carried out at the Department of Obstetrics & Gynecology, Lady Aitchison Hospital, Lahore on 160 females, who underwent ultrasonography by experienced radiologists. Cerebroplacental ratio and umbilical artery waveform was noted in form of resistive index (RI). Patients were categorized as positive or negative for respective methods. Females then underwent clinical evaluation for IUGR by experienced gynaecologists, and all the data was collected through proforma, entered and analyzed through SPSS 21. Sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV) and diagnostic accuracy of cerebroplacental ratio and umbilical artery waveform was measured.

Results: The patients had mean age of 29.16 ± 6.92 years. The mean gestational age at enrollment was 35.58 ± 1.08 weeks. At recruitment, the mean systolic blood pressure of females was 168.97 ± 13.71 mmHg and diastolic blood pressure was 108.32 ± 8.56 mmHg. There were 142 (68.75%) patients with pregnancy induced hypertension while 18 (11.25%) had eclampsia. The mean BMI of patient was 24.14 ± 3.39kg/m2. The specificity, sensitivity, NPV, PPV and diagnostic accuracy of cerebroplacental ratio were 95.1%, 96.97%, 95.1%, 96.97% and 96.25% respectively whereas of umbilical artery waveform were 49.2%, 71.7%, 51.7%, 96.6% and 63.1%.

Conclusion: The cerebroplacental ratio was more accurate than umbilical artery waveform for prediction of IUGR in hypertensive pregnancy.

Keywords: Cerebroplacental ratio, umbilical artery waveform, intrauterine growth retardation, hypertensive pregnancy, eclampsia, pregnancy induced hypertension, preeclampsia

Introduction

Placental malfunction during pregnancy is intimately linked to pre-eclampsia and pregnancy-induced hypertension, which can lead to intrauterine growth restriction.[1] When the ultrasound-estimated fetal weight is less than the 10th percentile for the gestational age, intrauterine growth restriction (IUGR) is detected. Around the world, IUGR affects 23.8% of newborns, with 75% of affected babies being born in Asia.[2] About 25% of pregnant ladies in Pakistan, especially in Karachi, were discovered to have IUGR.[3] Doppler ultrasonography velocimetry of the umbilical, fetal, and uteroplacental arteries is now a recognized technique for prenatal surveillance and is crucial for the detection of defective placentation. Adverse perinatal outcomes are predicted by alterations in circulation, which are evident in specific fetal Doppler waveforms.[1] Diagnosis of new hypertension is confirmed after 20 weeks of gestation if the patient's blood pressure exceeds 140/90 mmHg four hours apart, and if there is absence of protein in the urine.[4] Preeclampsia is defined as gestational hypertension and proteinuria (>300 mg of protein in a 24-hour urine sample).[1] The most frequent cause of hypertension in expectant mothers, accounting for 5–10% of cases, is gestational hypertension.[5] It is a leading factor in the morbidity and death of both mother and fetus.[6] Pre-eclampsia, however, is more common in nulliparas (3%–7%) than multiparas (1%–3%).[7]

For the evaluation of umbilical and uterine arteries, Doppler ultrasound examination has emerged as a useful technique in uteroplacental circulation detection, starting at an early stage of pregnancy. It has also been suggested as a possible screening tool for the onset of fetal growth restriction and pre-eclampsia.[8,9] For prenatal prediction, the cerebroplacental ratio (the ratio of the middle cerebral artery's pulsatility index to the umbilical artery) has superior sensitivities and specificities than the umbilical artery alone.[9,10] Obesity, age 35 or older, a history of diabetes, hypertension, and renal diseases, teenage pregnancy, new paternity, thrombophilias, multiple gestations (twins, triplets, etc.), placental abnormalities, a family history of pre-eclampsia, and African American race are the main risk factors for gestational hypertension.[11] In routine practice, the umbilical artery waveform is commonly used to predict whether IUGR is present or if the fetus has normal growth. However, literature suggests that the cerebroplacental ratio is more valuable than the umbilical artery waveform, though no local evidence has been found in the literature. Typically, studies have combined the umbilical artery and cerebroplacental ratio for predicting IUGR, but to find a more accurate and reliable method, we aim to conduct this study to enhance our understanding and application. In the future, we intend to use the study's findings in a local context. Therefore, the purpose of this study was to assess the diagnostic accuracy of the cerebroplacental ratio versus the umbilical artery waveform for predicting IUGR in hypertensive pregnancies. The goal was to compare the diagnostic accuracy of the umbilical artery waveform against the cerebroplacental ratio for predicting IUGR in hypertensive pregnancies undergoing clinical examination.

Methodology

This cross-sectional study was carried out from August 2018 to February 2019 at Lady Aitchison Hospital, Lahore (OBG-2015-066-6880). Using actual fetal weight for the given gestational age assessed at term via ultrasound, a sample size of 160 cases was determined through non-probability sampling. The statistical analysis was based on a 95% confidence level, an expected IUGR proportion of 25%, the sensitivity and specificity of the umbilical artery waveform (67% and 90%, respectively), and a margin of error of 5.5%. Among the inclusion criteria were women between the ages of 18 and 40, with a parity of less than 5, who presented with hypertension (blood pressure ≥140/90 mmHg 4 hours apart) at gestational age >32 weeks (on LMP).

Exclusion criteria included females with chronic or gestational diabetes (BSR>186mg/dl), anemia (HB<10mg/dl), those suffering from cardiac problems and taking medication during pregnancy (on medical record) and females with placental abnormalities (previa, accrete, increta or placental abruption) on USG, and very lean females (BMI<19kg/m2). Data collection involved the use of a self-structured questionnaire after obtaining ethical approval and informed consent.

Cerebroplacental ratio and umbilical artery waveform were assessed on ultrasonography by senior consultant radiologist. IUGR was confirmed if fetal weight was less than 10th percentile on ultrasound for particular gestational age near term or before delivery. All collected data was analyzed through SPSS 21. By assessing IUGR using fetal weight for a specific gestational age, 2x2 tables were created to evaluate the sensitivity, specificity, PPV, NPV, and diagnostic accuracy of both the umbilical artery waveform and the cerebroplacental ratio.

Results

The mean age of patients was 29.16 ± 6.92 years. In this study, 40 (25%) females were primigravida (nulliparous), 77 (48.2%) had parity of 1-2, and 43 (26.8%) had parity of 3-4. For each patient's parity, the data was stratified.

The mean gestational age at presentation was 35.58 ± 1.08 weeks. At presentation, the mean blood pressure of females was 168.97 ± 13.71 mmHg while diastolic blood pressure was 108.32 ± 8.56 mmHg. There were 142 (68.75%) patients with pregnancy induced hypertension while 18 (11.25%) had eclampsia (Figure- 1). The mean BMI of patient was 24.14 ± 3.39 kg/m2 (Table-1).

During clinical evaluation, the cerebroplacental ratio demonstrated a specificity of 95.1%, sensitivity of 96.97%, NPV of 95.1%, PPV of 96.97%, and overall diagnostic accuracy of 96.25%. In contrast, the umbilical artery waveform showed a specificity of 49.2%, sensitivity of 71.7%, NPV of 51.7%, PPV of 96.6%, and diagnostic accuracy of 63.1% (Table-2).

Table 1: Basic Demographics of Females

Number of Patients	160
Age (in years)	29.16 ± 6.92
Gestational age (weeks)	35.58 ± 1.08
Parity	
Primigravida	40 (25%)
Parity 1-2	77 (48.2%)
Parity 3-4	43 (26.8%)
Systolic Blood pressure (mmHg)	168.97 ± 13.71
Diastolic blood pressure (mmHg)	108.32 ± 8.56
Pregnancy induced hypertension	142 (68.75%)
Eclampsia	18 (11.25%)
BMI (kg/m2)	24.14 ± 3.39

Table 2: Accuracy of Cerebroplacental Ratio and Umbilical Artery Waveform Based on Clinical Evaluation

		Clinical Examination		Total
		Positive	Negetive	
Cerebroplacental ratio	Positive	96	3	99
	Negetive	3	58	61
Total		99	61	160
Umbilical artery waveform	Positive	71	31	102
	Negetive	28	30	58
Total		99	61	160

There were 142 (68.75%) patients with pregnancy induced hypertension while 18 (11.25%) had eclampsia.

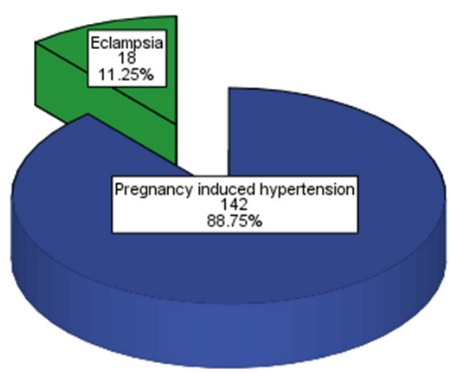

Figure -1: Distribution of severity of blood pressure among the 160 patients

Discussion

This study was undertaken to assess the diagnostic accuracy of the cerebroplacental ratio versus the umbilical artery waveform for predicting IUGR in hypertensive pregnancies. We wanted to compare the diagnostic accuracy of the umbilical artery waveform against the cerebroplacental ratio for predicting IUGR in hypertensive pregnancies undergoing clinical examination. In our study, the sensitivity, specificity, PPV, NPV and diagnostic accuracy of cerebroplacental ratio were 96.97%, 95.1%, 96.97%, 95.1% and 96.25% whereas of umbilical artery waveform were

71.7%, 49.2%, 96.6%, 51.7% and 63.1% on clinical evaluation. Similar study has showed that the sensitivity, specificity, PPV and NPV of umbilical artery waveform were 67%, 90%, 42% and 96% respectively, while for cerebroplacental ratio were 90%, 95%, 6% and 98%.[10] Doppler indices are a crucial part of the noninvasive assessment of the health of the fetus. Normal obstetric Doppler indices are not well documented, especially in the Indian subcontinent.[12] When evaluating different prenatal and perinatal problems, the cerebroplacental ratio is a stronger indication of fetoplacental circulation than umbilical artery waveform examination alone.[5,13] According to one study conducted by Ropacka-Lesiak et al. (2015), the cerebroplacental ratio's sensitivity, specificity, PPV, and NPV were 87.8%, 68.5%, 51.4%, and 93.7%, respectively, in predicting an unfavorable neonatal outcome.[14] Munikumari et al. (2017) reported that the umbilical artery waveform has a sensitivity of 91% and a specificity of 84.6% for IUGR prediction.[15] A study conducted in 2004 examined the relationships between umbilical artery (UA) Doppler, ductus venosus (DV) Doppler, fetal heart rate variation, and perinatal outcomes in preterm, intrauterine growth-restricted (IUGR) fetuses.[16] Majadla et al. (2024) found the umbilical artery waveform to have a sensitivity of 64% and a specificity of 90.7%.[17]

However, Fong et al. (1999) observed the sensitivity and specificity of the umbilical artery waveform to be 44.7% and 86.6%, respectively.[18] In contrast, Dhand et al. (2011) reported that in a comparable setup, IUGR could be predicted with a sensitivity of 44% and a specificity of 61.5%.[19] In a related study, Lakhkar et al. (2006) found that the umbilical artery waveform has a 44.4% sensitivity, 81.8% specificity, 80% positive predictive value, and a 47.3% negative predictive value for predicting any major adverse outcome, such as neonatal IUGR, in pregnancies that are complicated by severe preeclampsia, IUGR, or both, and that are beyond 30 weeks of gestation.[20] According to Ibrahim et al. (2014) the umbilical artery waveform may predict newborn IUGR in hypertensive pregnancies with a high sensitivity of 94.8% and a poor specificity of 36.8%.[21] Placental insufficiency, which happens when the trophoblast is unable to pierce sufficiently deeply into the uterine lining, is the most common cause of IUGR.[22] When the trophoblast of the fetus fails to penetrate the uterine wall, the spiral arteries do not undergo a complete transformation into low-resistance channels.[23] This insufficient conversion of spiral arteries increases the barrier to uterine blood flow during pregnancy and has been associated with gestational hypertension.[24] An erroneous immunological reaction by the mother's tissue to the alien foetal tissue may be one cause of this partial rupture of the spiral arteries, which causes gestational hypertension.[25] As a result, the fetus modifies its circulation to protect the brain's supply of oxygen and nutrients (a process known as "brain-sparing"). Currently, not much is understood regarding the postnatal progression and implications of this antenatal cerebral circulation adaptation. A different approach to cerebral monitoring and clinical management of IUGR preterm newborns than their correctly developed counterparts would be necessary if the abnormal cerebral haemodynamics were to remain after birth. There aren't many research articles on this subject, and little that is known is also disputed.[26]

Cerebroplacental ratio reflects the status of redistribution of the cardiac output to the cerebral circulation, which improves accuracy in predicating adverse outcome compared to middle cerebral artery and umbilical artery Doppler alone.[27] The cerebroplacental ratio is also considered to be more physiological in the measurement of centralization of fetal blood flow. Srikumar et al. (2017) found that cerebroplacental ratio showed a strong positive correlation with gestation age till 30 weeks of gestation followed by strong negative correlation thereafter till 40 weeks of gestation. This is probably due to different amount of blood volume required by brain in different gestation. There is paucity of information in the literature on this account.[12] There are few studies, which have tried to formulate reference ranges for cerebroplacental ratio over the gestation period in normal pregnancies.[28] Umbilical cord plays a crucial role in fetal health and development. Several complications like IUGR, cord accidents, and stillbirths are attributed to an abnormal fetoplacental circulation. In conclusion, understanding and monitoring fetoplacental circulation, particularly through measures like the cerebroplacental ratio and umbilical artery waveform, are crucial for identifying potential complications such as IUGR, cord accidents, and stillbirths. Continued research and the development of precise reference ranges for these measures throughout gestation can significantly enhance prenatal care and improve fetal outcomes.

Limitations

Firstly, the study's sample size is somewhat limited, with only 160 patients from a single hospital, which may not represent the broader demographic of our hypertensive patients. Secondly, the cost-effectiveness of implementing the cerebroplacental ratio (CPR) over Doppler waveform was not addressed. Lastly, the study uses clinical evaluation of IUGR, which can sometimes be subjective.

Authors' Contributions

SIS conceived and designed the study, participated in data collection, and contributed to draft-ing and revising the article. IN supervised and critically revised and analysed the work, and gave intellectual input.

Conclusion

Cerebroplacental ratio was more accurate than umbilical artery waveform for prediction of IUGR in hypertensive pregnancy. Now we can implement the use of cerebroplacental ratio instead of umbilical artery waveform for prediction of IUGR in our setting, as it found to be more accurate than umbilical artery waveform. This would help to improve our knowledge and practice.

Conflict of Interest: The authors have no conflict of interest.

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