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COMPARATIVE ACCURACY OF UMBILICAL ARTERY DOPPLER AND MIDDLE CEREBRAL ARTERY DOPPLER INDICES FOR PREDICTION OF ADVERSE OUTCOMES IN FETAL GROWTH RESTRICTIONS

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ABSTRACT

Background: Fetal growth restriction (FGR) is associated with increased risks of fetal hypoxia, neonatal morbidity, NICU admission, and perinatal mortality.

Objective: To compare the diagnostic accuracy of umbilical artery and middle cerebral artery Doppler indices for predicting adverse perinatal outcomes in pregnancies complicated by fetal growth restriction.

Methods: This prospective observational diagnostic-accuracy study was conducted at Obstetrics and Gynecology department of Lahore General Hospital from July 2020 to January 2021, included 91 pregnant women with FGR. Maternal characteristics, fetal biometry, UA pulsatility index (UA-PI), UA systolic/diastolic (S/D) ratio, and MCA pulsatility index (MCA-PI) were recorded. Participants were followed until delivery, and neonatal outcomes including birth weight, Apgar score, NICU admission, NICU stay, neonatal complications, and adverse perinatal outcome were assessed.

Results: Mean MCA-PI was significantly lower in SGA fetuses than in non-SGA fetuses (1.22±0.50 vs. 1.48±0.49; p=0.017), while mean UA S/D ratio was significantly higher (3.26±1.08 vs. 2.80±0.84; p=0.023). Mean UA-PI did not differ significantly between groups (1.05±0.41 vs. 0.97±0.33; p=0.571). The UA S/D ratio demonstrated the highest sensitivity (50.62%) and overall diagnostic accuracy (54.95%), with 90.00% specificity and 97.62% PPV. MCA-PI showed 35.80% sensitivity but achieved 100.00% specificity and 100.00% PPV. UA-PI showed the lowest sensitivity (29.63%) and diagnostic accuracy (36.26%).

Conclusion: It is concluded that both UA and MCA Doppler indices are useful in predicting adverse perinatal outcomes in fetal growth restriction. The UA S/D ratio showed the best overall sensitivity and diagnostic accuracy, whereas MCA-PI provided the highest specificity and positive predictive value.

KEYWORDS: Fetal growth restriction; umbilical artery Doppler; middle cerebral artery Doppler; pulsatility index

INTRODUCTION

Fetal growth restriction (FGR) is an important obstetric complication defined as a failure of the fetus to reach his or her genetically determined growth potential. It has been defined as an estimated fetal weight or abdominal circumference that falls below the 10th percentile for gestational age and occurs in up to 10% of pregnancies [1]. FGR is linked to stillbirth, fetal hypoxia, neonatal intensive care unit (NICU) admission, low Apgar score, metabolic acidosis, preterm delivery, long-term neurological and cardiovascular complications [2,3]. One of the main causes of FGR is placental insufficiency, which leads to the loss of transfer of oxygen and nutrients to the growing fetus [4]. The Doppler ultrasonography has been a routine part of fetal surveillance since it allows a non-invasive estimate of the fetoplacental and fetal circulatory changes [5]. Umbilical artery (UA) Doppler assesses resistance in the placental blood flow. With progression of placental dysfunction, UI pulsatility index (PI) will increase, and in severe cases, end-diastolic (ED) flow can disappear or reverse, corresponding to a rise in perinatal morbidity/mortality [6,7]. For this reason, UA Doppler is widely advised for the monitoring of pregnancies complicated by FGR and is known to be an important for determining the timing and frequency of monitoring. [8]

Middle cerebral artery (MCA) Doppler gives information about fetal adaptation to hypoxemia. When oxygen supply is limited, cerebral vasodilatation happens, resulting in a decrease of MCA-PI which is known as the fetal "brain-sparing" response [9]. This shift in cardiac output can be an independent marker of fetal deterioration prior to other fetal parameters and can be helpful in assessing fetal compromise, especially in the late onset FGR where UA Doppler may be normal [10]. The cerebroplacental ratio (CPCR) has also been studied as combined MCA-PI and UA-PI as an indicator of fetal and placental hemodynamic status [11]. The relative predictive accuracy of UA and MCA Doppler indices is still not clear, though. Recent studies have shown that all three UA-PI, MCA-PI and cerebroplacental Doppler indices are predictive of adverse perinatal outcome, but the values of each are dependent on gestational age, reference standards and the severity of FGR [12,13]. Both large cohorts indicated a similar level of sensitivity (58.5% to 67.4% for UA-PI and 55.4% to 61.4% for MCA-PI) for predicting adverse perinatal outcomes [14]. There are also different recommendations internationally: UA Doppler is now the main instrument for the routine FGR monitoring, and the routine use of MCA Doppler is still being discussed, especially in early onset disease [15].

Objective

To compare the diagnostic accuracy of umbilical artery and middle cerebral artery Doppler indices for predicting adverse perinatal outcomes in pregnancies complicated by fetal growth restriction.

METHODOLOGY

This prospective observational diagnostic-accuracy study was conducted at conducted at Obstetrics and Gynecology department of Lahore General Hospital from July 2020 to January 2021. A total of 91 pregnant women with clinically and sonographically diagnosed fetal growth restriction (FGR) were enrolled. The sample size was based on a published comparative study evaluating middle cerebral artery (MCA) and umbilical artery (UA) Doppler indices in FGR pregnancies. Singleton pregnancies between 28 and 38+6 weeks of gestation were included. FGR was defined as an estimated fetal weight (EFW) or abdominal circumference (AC) below the 3rd percentile, or below the 10th percentile in association with abnormal UA, MCA, or cerebroplacental Doppler findings. Multiple gestations, fetuses without growth restriction, congenital malformations, and chromosomal abnormalities were excluded.

Data Collection

After approval from the institutional ethical review committee and written informed consent, maternal demographic and obstetric information including age, parity, body mass index, gestational age, and relevant clinical history was recorded. All participants underwent fetal biometry and Doppler ultrasonography. UA Doppler was obtained from a free-floating loop of the umbilical cord, and the UA pulsatility index (PI) and systolic/diastolic (S/D) ratio were recorded. An UA S/D ratio ≥3 or UA-PI above the 95th percentile was considered abnormal. MCA Doppler was obtained from the proximal MCA near the greater wing of the sphenoid with an insonation angle of approximately 0–15°, and MCA-PI was recorded; an MCA-PI below the 5th percentile was considered abnormal. Pregnancies were followed until delivery. Neonatal outcomes included birth weight, birth weight below the 10th percentile, mode of delivery, Apgar score ≤7, NICU admission, NICU stay >48 hours, neonatal complications, and perinatal mortality. Following delivery, neonates were categorized as small for gestational age (SGA) when birth weight was below the 10th percentile and as non-SGA when birth weight was ≥10th percentile. The predictive performances of UA-PI, UA S/D ratio, and MCA-PI for adverse perinatal outcomes were subsequently compared.

Statistical Analysis

Data were analyzed using SPSS version 21.0. Continuous variables were presented as mean±standard deviation and compared using the independent-samples t-test or Mann–Whitney U test according to data distribution. Categorical variables were expressed as frequencies and percentages and compared using the chi-square test or Fisher's exact test. Diagnostic accuracy of MCA-PI, UA-PI, and UA S/D ratio was assessed by calculating sensitivity, specificity, positive predictive value, negative predictive value, and overall diagnostic accuracy. A p-value <0.05 was considered statistically significant.

RESULTS

The SGA and non-SGA groups were broadly comparable for maternal characteristics. Mean maternal age was 28.77±4.79 years in the SGA group and 27.50±3.80 years in the non-SGA group (p=0.261), while mean BMI was 23.99±4.61 versus 23.81±2.91 kg/m² (p=0.946). Primiparity was present in 31 (44.91%) and 11 (50.00%) women, respectively. Oligohydramnios was significantly more frequent in SGA pregnancies, occurring in 31 (44.93%) compared with 3 (13.64%) non-SGA pregnancies (p=0.011).

Table 1. Baseline clinical characteristics of the study participants

Characteristic	SGA (n=69)	Non-SGA (n=22)	p-value
Maternal age (years)	28.77±4.79	27.50±3.80	0.261
BMI (kg/m²)	23.99±4.61	23.81±2.91	0.946
Primiparous	31 (44.91%)	11 (50.00%)	0.678
Multiparous	38 (55.07%)	11 (50.00%)	

Pre-eclampsia	10 (14.49%)	0 (0%)	0.111*
Gestational hypertension	9 (13.04%)	2 (9.09%)	
Gestational diabetes	15 (21.74%)	6 (27.27%)	
Oligohydramnios	31 (44.93%)	3 (13.64%)	0.011
Normal amniotic fluid	38 (55.07%)	19 (86.36%)	

SGA neonates had a significantly lower mean birth weight of 1.85±0.49 kg compared with 2.53±0.23 kg in the non-SGA group (p<0.0001). NICU admission was required in 47 (70.15%) versus 7 (31.82%) neonates (p=0.001), while mean NICU stay was 9.15±12.94 versus 2.50±1.05 days (p=0.018). Neonatal complications occurred in 42 (61.76%) versus 5 (22.73%) cases (p=0.001), and adverse perinatal outcomes were reported in 69 (100%) SGA compared with 12 (54.55%) non-SGA neonates (p<0.0001).

Table 2. Comparison of perinatal outcomes between SGA and non-SGA neonates

Outcome	SGA (n=69)	Non-SGA (n=22)	p-value
Cesarean delivery	41 (59.42%)	8 (36.36%)	0.059
Vaginal delivery	28 (40.58%)	14 (63.64%)	
Mean birth weight (kg)	1.85±0.49	2.53±0.23	<0.0001
Birth weight <3rd percentile	49 (71.01%)	0 (0%)	<0.0001
Birth weight 3rd–10th percentile	20 (28.99%)	0 (0%)	
5-minute Apgar score ≤7	5 (7.25%)	0 (0%)	0.331
NICU admission	47 (70.15%)	7 (31.82%)	0.001
NICU stay (days)	9.15±12.94	2.50±1.05	0.018
Neonatal complications	42 (61.76%)	5 (22.73%)	0.001
Adverse perinatal outcome	69 (100%)	12 (54.55%)	<0.0001

The mean MCA pulsatility index was significantly lower in SGA fetuses, 1.22±0.50 compared with 1.48±0.49 in non-SGA fetuses (p=0.017), indicating greater cerebral redistribution. Mean UA-PI was 1.05±0.41 versus 0.97±0.33, with no significant difference (p=0.571). In contrast, the mean UA S/D ratio was significantly higher in SGA pregnancies, 3.26±1.08 versus 2.80±0.84 (p=0.023).

Table 3. Comparison of fetal Doppler indices between SGA and non-SGA pregnancies

Doppler Index	SGA (n=69)	Non-SGA (n=22)	p-value
Middle cerebral artery PI	1.22±0.50	1.48±0.49	0.017
Umbilical artery PI	1.05±0.41	0.97±0.33	0.571
Umbilical artery S/D ratio	3.26±1.08	2.80±0.84	0.023

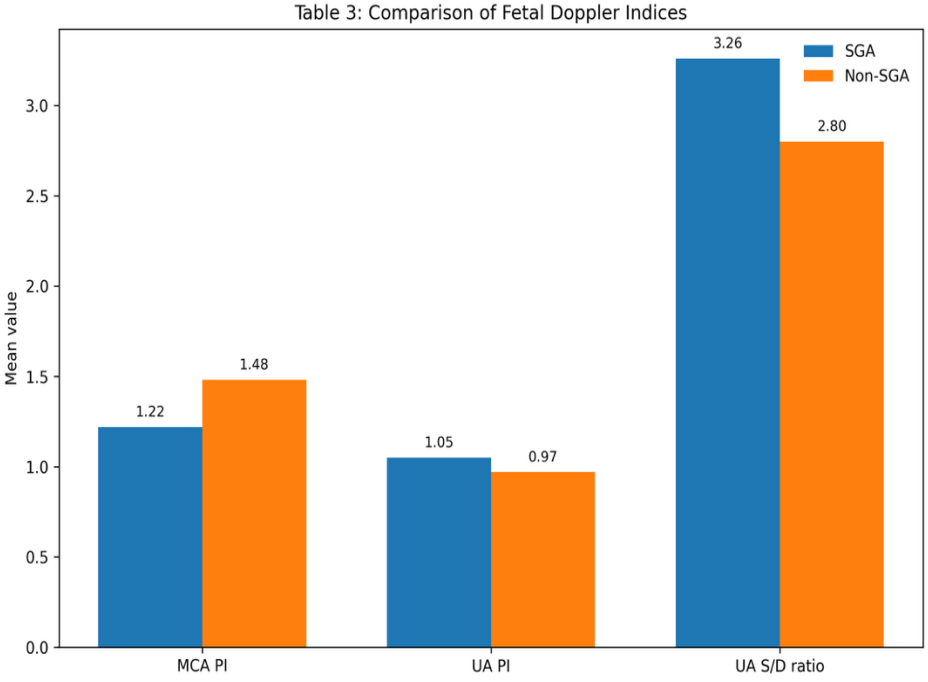


Figure 1. Comparison of Fetal Doppler Indices Between SGA and Non-SGA Pregnancies

Among the Doppler parameters, the UA S/D ratio showed the highest sensitivity at 50.62%, with 90.00% specificity, 97.62% PPV, 18.37% NPV, and the highest overall diagnostic accuracy of 54.95%. MCA-PI had lower sensitivity at 35.80% but demonstrated 100.00% specificity and 100.00% PPV, with 16.13% NPV and 42.86% accuracy. UA-PI showed the lowest sensitivity and accuracy at 29.63% and 36.26%, respectively, with 90.00% specificity, 96.00% PPV, and 13.64% NPV.

Table 4. Diagnostic accuracy of Doppler indices for predicting adverse perinatal outcome

Doppler Parameter	Sensitivity	Specificity	PPV	NPV	Diagnostic Accuracy
MCA-PI	35.80%	**100.00%**	**100.00%**	16.13%	42.86%
UA-PI	29.63%	90.00%	96.00%	13.64%	36.26%
UA S/D ratio	**50.62%**	90.00%	97.62%	**18.37%**	**54.95%**

DISCUSSION

In the present study, the authors compared umbilical artery and middle cerebral artery Doppler parameters to determine their value in predicting adverse perinatal outcomes in fetuses with FGR. Maternal age and BMI were similar between the two groups (SGA vs. non-SGA); the mean ages of the mothers were 28.77±4.79 and 27.50±3.80 years, respectively, while the mean BMI was 23.99±4.61 and 23.81±2.91 kg/m². A significant association was made between SGA and oligohydramnios (44.93% vs. 13.64%; p=0.011). In previous studies, oligohydramnios was also proven to be a significant part of risk evaluation in FGR, especially if associated with abnormal Doppler [16]. Neonatal outcome was significantly worse in SGA fetuses. There was a significant difference in mean birth weight, 1.85±0.49 kg versus 2.53±0.23 kg in non-SGA neonates (p<0.0001). NICU admission occurred in 70.15% versus 31.82% (p=0.001), while mean NICU stay was 9.15±12.94 versus 2.50±1.05 days (p=0.018). Neonatal complications were also more common among SGA neonates as well (61.76% vs. 22.73%, p=0.001). Other studies with over 1100 growth-restricted pregnancies also have found that 28% of these pregnancies had to be admitted to the neonatal intensive care unit (NICU) and that there was a strong correlation between severity of growth restriction, abnormal fetal Doppler findings and adverse perinatal outcomes [17]. The mean MCA pulsatility index was significantly lower for the SGA fetuses (1.22 ± 0.50) than for fetuses not-SGA (1.48 ± 0.49) (p=0.017). This is a finding of cerebral vasodilatation or the brain-sparing response that occurs with fetal hypoxemia. Earlier studies have also shown higher rates of abnormal cerebral artery pulsatility in growth-restricted fetuses and the abnormal cerebral Doppler has been correlated with low birth weight and high rate of NICU admission [18]. UA S/D ratio was significantly higher in pregnancies that were SGA than in those that were not SGA (3.26±1.08 vs. 2.80±0.84, p=0.023). In contrast, the mean UA-PI was 1.05±0.41 versus 0.97±0.33 and did not differ significantly (p=0.571). Previous studies with 296 pregnancies with FGR also confirmed that the UA S/D ratio is clinically relevant, with 47% of infants being admitted to the NICU and the conventional UA S/D ratio having a predictive value of ~0.81–0.82 when the most severely growth-restricted fetuses were considered [19].

The UA S/D ratio, in the present study, had the highest sensitivity (50.62%) and overall diagnostic accuracy (54.95%), with a high specificity (90.00%) and PPV (97.62%). In a previous study comparing Doppler indices in 80 pregnancies with FGR, umbilical artery Doppler was the most sensitive index of adverse perinatal outcome, and abnormal fetal arterial pulsatility index was found to be significantly associated with perinatal complications with a sensitivity of 66% [20]. In prior prospective studies, a UA S/D ratio of >3.0 was also shown to be a good predictor of adverse outcome with sensitivity of 79%, specificity of 93%, PPV 83%, and NPV 91% [21]. Possible differences are due to gestational age, FGR severity, Doppler reference ranges and definition of adverse outcome between studies. There were a number of limitations to this study. Sample size was small, and might have limited the precision of the estimates of diagnostic accuracy, especially for sensitivity and negative predictive value. The study, of course, was carried out at a single center, and results may not be applicable in other locations. Doppler measurements are also operator dependent and might be affected by fetal movement, gestational age and technical variability. In addition, adverse perinatal outcome was analyzed as a composite endpoint, which may have multiple outcomes of varying severity. Other potentially useful parameters were not included in the main comparison: cerebroplacental ratio, ductus venosus Doppler, and serial Doppler changes.

CONCLUSION

It is concluded that both umbilical artery and middle cerebral artery Doppler indices are useful for predicting adverse perinatal outcomes in pregnancies complicated by fetal growth restriction. The umbilical artery S/D ratio showed the highest sensitivity and overall diagnostic accuracy, whereas MCA-PI demonstrated the highest specificity and positive predictive value. These findings suggest that UA Doppler may be more useful for screening and overall risk prediction, while MCA Doppler can provide additional value in identifying fetuses with significant cerebral redistribution.

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