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The relationship of the umbilical artery half peak systolic velocity deceleration time with postpartum Apgar scores and umbilical cord blood pH in pregnancy with fetal growth restriction

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ABSTRACT

Objectives: This study aims to examine the correlation between neonatal reactions and umbilical artery half peak systolic velocity deceleration time (UA HPSVDT)

Material and methods: For the research, participants were selected among 24–40 weeks pregnant women. While the study group consisted of those with fetal growth restriction (FGR), the control group included the rest. To determine UA HPSVDT and certain Doppler parameters, Doppler ultrasonography was used and within a week before delivery, the middle cerebral artery (MCA Doppler was obtained). Likewise, a peri-operatively taken blood sample made it possible to determine Cord blood pH. Apgar scores of neonates were assessed within the 1^{st}–5^{th} minutes.

Results: In terms of fetal weight, cord blood pH, 1^{st} and 5^{th} minute Apgar scores and UA HPSVDT (for all parameters $p < 0.01$), a significant statistical difference was found between FGR and control groups. On the other hand, a significant correlation among neonatal weight, cord blood pH, 1^{st}–5^{th} minute Apgar scores and UA HPSVDT were observed. It was clear that in the FGR group (for all parameters $p < 0.01$), the Apgar scores, cord blood pH, and neonatal weight decreased as the UA HPSVDT decreased. However, between UA HPSVDT and other variables, no remarkable statistical significance was determined.

Conclusions: The research makes it clear that the UA HPSVDT time is related to umbilical artery of blood pH levels and post-natal Apgar scores; therefore, it can be useful for efforts to minimize the rate of mortality and morbidity in perinatal practices.

Keywords: fetal growth restriction; umbilical artery Doppler; umbilical artery half peak systolic velocity deceleration time

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INTRODUCTION

Placental inadequacy is a medical condition which creates fetal growth restriction (FGR). The main pathology in placental insufficiency is increased vascular resistance [1, 2]. In the assessment of the FGR by monitoring vascular changes, umbilical artery (UA) has a remarkable role [3]. Compared to the Doppler of the middle cerebral artery and ductus venosus, clinical significance of umbilical artery Doppler is a greater importance in diagnosis and management of FGR.

Systolic/diastolic ratio, pulsatility index (PI) and resistance index (RI) make up umbilical artery's core indices. A recently introduced umbilical artery parameter is umbilical artery half-peak systolic velocity deceleration time (UA HPSVDT), which reveals the period of time between half of the wave and PSV [4]. It is clear that UA HPSVDT is directly proportional to vascular compliance while it is also inversely proportional to vascular resistance. A study in pediatric cardiology to determine and diagnose the aortic coarctation severity supports this hypothesis.

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To detect neonatal reactions, Apgar scores are commonly resorted. Likewise, fetal umbilical cord arterial blood pH is also used to foresee fetal acidosis, which has inflictions on FGR.

This study aims to investigate if UA HPSVDT, fetal umbilical cord arterial blood pH, Apgar scores and middle cerebral artery (MCA) Doppler are correlated. Hence, to predict perinatal reactions by measurement, a new Doppler index called UA HPSVDT can be used.

MATERIAL AND METHODS

This study analyzed in prospective research 60 healthy, singleton and elaborately-informed pregnant women on consent, 30 of whom were complicated with FGR and the other 30 with healthy fetuses in accordance with the pre-determined criteria during their visit to Ege University Faculty of Medicine Department of Gynecology within the period of December 2016 and March 2017. Ethical approval was obtained for this study from the local ethics committee of Ege University Hospital (No: 16-9/2). Weeks of pregnancies were calculated according to their last menstruation dates (LMD) and confirmed by the first-trimester crown-rump length (CRL) measurements. Pregnant women with fetal congenital anomalies or infections were not included in the study.

Those with fetuses of FGR formed the study group while the ones with healthy fetuses formed the control group. The parameters of fetal biometry, umbilical artery, and MCA established by the same perinatology specialist *via* Voluson E8 Expert Ultrasound (USG) made the calculation of umbilical artery half peak systolic velocity deceleration time (HPSVDT) possible. All Doppler evaluations were carried out during fetal apnea when there were no fetal movements and at least 3 similar waves were observed with the ultrasonic angle being less than 45°. The umbilical artery Doppler was performed from the free end of the umbilical cord. The biggest form of the systolic wave was utilized for measurement of umbilical artery pulsatility index (PI) and HPSVDT. The umbilical artery half-peak systolic velocity deceleration time (HPSVDT) was reached after calculating the period of the descent that the umbilical artery waveform underwent from the maximum level down through the half. Middle cerebral artery Doppler evaluation was conducted in the axial part of the fetal brain at 2 mm ahead of the tip of the vein without applying any pressure on the fetal head during which the angle of insonation was closest to 0. Those who appeared to have fetuses with week-based estimated fetal weight (EFW) of less than 10% percentile were assigned as the study group whereas the ones that had fetuses with EFW of more than 10% percentile were specified as the control group. The amniotic fluid index of each pregnant woman was calculated for conditions of amniotic fluid, which culminated in the specification of those under 5% percentile as oligohydramnios. Observations upon each pregnant woman were realized in the light of obstetric indications. All pregnant women were taken into follow-up with their Doppler parameters being measured weekly. Besides, their last Doppler parameters up until 7 days prior to labor were statistically evaluated. During labor, 5cc cord blood was taken from each into EDTA tubes to reach an immediate result of umbilical cord blood pH. The 1st and 5th minute Apgar scores of the newborns were evaluated by a pediatrician.

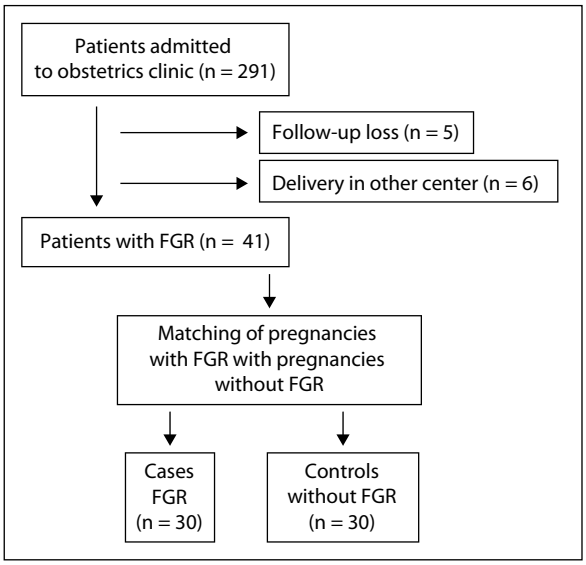


Figure 1. CONSORT flow diagram of the case-control study; FGR — fetal growth restriction

In this study, the sample size was calculated at the 95% confidence interval using the „G-Power-3.1.9.7" program. Based on a previous similar study, the minimum sample size (case + control) was calculated as 75 with a theoretical power of 0.80 and an acceptable margin of error of 0.05 alpha, depending on the FGR and HPSVDT status [5]. However, the sample size remained at 60 (30 cases + 30 control) due to missing data and follow-up loss (Fig. 1).

For the assessment of data, the study made use of SPPS 20 (IBM Corp. Released 2011. IBM SPSS Statistics for Windows, Version 20.0. Armonk, NY: IBM Corp.) statistics pack program. The variables were used as values of mean ± standard deviation and median (minimum–maximum). Moreover, the homogeneity of variances, which is one of the preconditions of parametric tests, was checked with the "Levene" test while the presumption of normality was checked with the "Shapiro–Wilk" test. In the evaluation of differences between the two groups, the study resorted to "Student's t-test" when the preconditions of parametric tests were met; however, it relied on the "Mann–Whitney-U test" when the conditions were otherwise.

During categorical analysis of data, Fisher's exact test and chi-square test were employed. In cases where the expected

cells were smaller than 20%, values were determined with the "Monte Carlo Simulation Method" to include the cells in the analysis. When the correlation between the two variables did not meet the preconditions of the parametric test, the study benefited from Kendall rank correlation coefficient. The statistical significance was regarded as < 0.05 and p < 0.01.

RESULTS

The study included 60 pregnant women, 30 of whom had FGR and the other 30 having normal fetuses. With regards to such variables as the neonatal weight, umbilical cord blood pH values, 1st and 5th minute Apgar scores, HPSVDT, gravidity and the week of birth (p < 0.01 for all) (Tab. 1), the study revealed a statistically significant difference between FGR and control groups. As for the FGR group, 14 women emerged to have regular amnion fluid while the rest 16 were determined to be oligohydramnios. Also, within this group, 3 had gestational hypertension and 9 were diagnosed with preeclampsia.

Umbilical artery half-peak systolic velocity deceleration time mean scores emerged to be 190 ± 13 ms and 120 ± 14 ms respectively in control and FGR groups (p < 0.01). On the other hand, Apgar 1st and 5th minute scores were respectively 9 and 10 in the control group and 6 and 8 in the FGR group (p < 0.01 for both). Blood pHs of the umbilical cord were found to be respectively 7.29 ± 0.04 and 7.22 ± 0.12 in control and FGR groups. On the other hand, neonatal weights were found to be respectively 3345 ± 401 g and 1407 ± 567 g in control and FGR group (p < 0.01). The study found a statistical significant relationship between MCA and umbilical artery Doppler variables within control and FGR groups. According to the FGR group umbilical artery Doppler variable, 26.7% had umbilical artery value of 5–95% percentile, 33.3% had umbilical artery PI value of over 95% percentile and 40% had a loss of diastolic flow. Conversely, umbilical artery Doppler values in the control group were 100% within normal range. Although 83.3% of PI variables of the MCA Doppler within the FGR group were below 5% and 16.7% was normal, 100% of the variables within the control group were found to be within normal ranges. Thus, it is possible to suggest FGR is related to impaired MCA and umbilical artery Doppler values. The results are shown in Table 1.

A significant difference was found among groups of the umbilical artery Doppler regarding umbilical cord blood pH and Apgar 1st and 5th minute mean scores. The findings obtained in the umbilical artery Doppler groups are as follows: The difference among the groups of the umbilical artery and the loss of diastolic flow in an umbilical artery (AEDF) is

Table 1. Comparison of variables between the groups

		FGR group (n = 30)	Control group (n = 30)	p value
Age [years] (mean ± SD)		28 ± 5	29 ± 6	0.51
Height [cm]		160 ± 5	163 ± 6	0.13
Weight [kg]		71 ± 15	74 ± 11	0.41
Pregnancy week at the time of delivery [weeks]		33 ± 3.1	37 ± 0.4	< 0.01*
Pregnancies 24–28 weeks (n)		0	0	
Pregnancies 28–32 weeks (n)		6	0	
Gravidity		2 ± 1.4	3 ± 0.9	< 0.01*
Umbilical artery Doppler	AEDF	12 (40%)	0 (0%)	< 0.01*
	PI > 95th percentile	10 (33.3%)	0 (0%)	
	PI = 5–95th percentile	8 (26.7%)	30 (100%)	
Middle cerebral artery Doppler	PI < 5th percentile			0.01*
	PI = 5th–95th percentile			
HPSVDT [ms]		120 ± 14	190 ± 13	< 0.01*
Apgar 1st minute score		6.4 ± 1.4	8.8 ± 0.4	< 0.01*
Apgar 5th minute score		8.2 ± 0.9	9.8 ± 0.4	< 0.01*
Umbilical cord blood pH		7.22 ± 0.12	7.29 ± 0.04	< 0.01*
Neonatal weight [g]		1407 ± 567	3345 ± 401	< 0.01*

AEDF — absence of end diastolic flow; FGR — fetal growth restriction; HPSVDT — half peak systolic velocity deceleration time; PI — pulsatility index; *statistically significant

Table 2. Comparison of middle cerebral artery and umbilical artery Doppler variables

	Umbilical artery Doppler			p value	MCA Doppler		p value
	AEDF (n = 12)	PI > 95th percentile (n = 10)	PI = 5th–95th percentile (n = 38)		PI < 5th percentile (n = 25)	PI = 5th–95th percentile (n = 35)	
Apgar 1st minute score	5.9	6.4	8.5	< 0.01*	6.6	8.3	< 0.01*
Apgar 5th minute score	7.9	8.0	9.8	< 0.01*	8.4	9.7	< 0.01*
Umbilical cord blood pH	7.18	7.20	7.29	< 0.01*	7.23	7.27	0.10

AEDF — absence of end diastolic flow; MCA — middle cerebral artery; PI — pulsatility index; *statistically significant

5th–95th percentile and the umbilical artery of > 95. percentile is statistically significant ($p < 0.01$ for all) (Tab. 2). Therefore, it is clear that impaired parameters of the umbilical artery Doppler are correlated with lower cord blood pH and Apgar scores.

Among the MCA Doppler groups in terms of Apgar 1st minute and 5th minute mean scores, a statistically significant difference was found. ($p < 0.01$ for both) (Tab. 2). Nonetheless, between cord blood pH and MCA Doppler, significant differences were not observed ($p = 0.10$). Thus, it can be claimed that impaired parameters of MCA Doppler are related with lower Apgar mean scores.

When UA HPSVDT and such other parameters as neonatal weight, cord blood pH and Apgar 1st and 5th minute scores were compared in control and FGR groups, it was clear that a significant correlation was observed between neonatal weight, cord blood pH, Apgar 1th–5th minute scores and UA HPSVDT in FGR group (for all $p < 0.01$; Spearman's rho correlation coefficients = 0.861, 0.728, 0.920, 0.581, respectively) (Tab. 3). On the other hand, no significant correlation among aforementioned parameters was found in control group ($p = 0.88$, $p = 0.99$, $p = 0.9$, $p = 0.29$, respectively). Hence, it can be asserted lower neonatal weight, cord blood pH and Apgar mean scores are correlated with lower UA HPSVDT.

DISCUSSION

One might suffer from a wide range of difficulties with timing of delivery and an optimal approach towards women with FGR on account of uteroplacental inadequacy. Ultrasonography for fetal biometry, biophysical profile and Doppler flow practices make it possible to extract significant data for evaluation of fetal conditions and their aftermath during pregnancy. This aims to identify the pregnant women carrying risks of neonatal morbidity and in-utero death and take necessary actions. It is useful in clinical routine as a non-invasive method to evaluate blood circulation. Doppler ultrasonography is also used to assess and interpret the fetal circulation in some veins, the most remarkable of which stands as the MCA, and umbilical artery [6]. Doppler ultrasonography is not only significant for examining fetal hemodynamics in these veins, but it also serves as guideline for identification of fetal welfare. A number of randomized studies demonstrate that umbilical artery Doppler is a fruitful method in identification of perinatal morbidity and mortality risky pregnancies. Thus, it stands as an ideal method for women with FGR. A compilation study revealed 29% decrease in the mortality rate among high-risk women who were applied Doppler of umbilical artery. Each woman within the FGR group in this study was applied a C-section (C/S) Due to its protective effect, MCA Doppler also provides significant

Table 3. Correlation of other parameters and half peak systolic velocity deceleration time (HPSVDT) in control and fetal growth restriction (FGR) groups

					p value
HPSVDT	FGR group	Spearman's rho correlation coefficient	Apgar 1st minute score	0.861*	< 0.01*
			Apgar 5th minute score	0.728*	< 0.01*
			Umbilical cord blood pH	0.920*	< 0.01*
			Neonatal weight	0.581*	< 0.01*
	Control group	Spearman's rho correlation coefficient	Apgar 1st minute score	0.029	0.88
			Apgar 5th minute score	–0.001	0.99
			Umbilical cord blood pH	0.308	0.09
			Neonatal weight	–0.198	0.29

hPSVdt — half peak systolic velocity deceleration time; FGR — fetal growth restriction; *statistically significant

data on the brains of fetuses with FGR. This can be regarded as normal when there is a breakdown in the autoregulation eventually due to a decrease in the Doppler parameters.

A study published by Ghosh et al. [7] among 353 women with singular pregnancies with FGR revealed abnormal flow in umbilical artery Doppler as 28.4%. Conversely, in this study this rate is 73.3 (22 patients), with 40% (12 patients) showing umbilical artery diastolic flow loss and 33.3% (10 patients) having resistance increase.

In another study, 100 pregnancies with FGR, 50 showing normal Doppler of umbilical artery and the other 50 having abnormalities in Doppler of umbilical artery were compared. They asserted intraventricular hemorrhage (18% to 6%), the preterm birth (96% to 14%), and perinatal mortality rate were found three times higher in the group with Doppler abnormalities [8].

Another study dealing with umbilical artery and MCA Doppler was conducted within a one-year period by Roy et al. [9] with 100 random single pregnant women with FGR, at the end of which it was confirmed that 43 had abnormal MCA PI. However, our study indicated that in terms of PI variable of MCA Doppler, while 100% of the control group was found to have normal values, 16.7% was within normal limits (5–95% percentile) and 83.3% of the FGR group was below 5%. Another study also asserted the intensive care need of newborn amounted to 68.1% with abnormal and 46.4% with normal MCA Doppler [9].

The same study also illuminated that abnormal MCA PI values are closely related to lower 5th minute Apgar scores A different study demonstrated the worse the scores of Apgar emerged, the worse the umbilical artery Doppler values got, which increased perinatal mortality and confirmed the intensive care need [10]. Another statistically significant point made in our study is that there is a decrease in 1st and 5th minute Apgar scores in conditions where an MCA and umbilical artery Doppler flows got worse ($p < 0.001$). Nevertheless, despite the statistical significance between umbilical cord blood pH and umbilical artery Doppler, this was not valid for the correlation between MCA Doppler and umbilical cord blood pH.

A significant parameter in our study, Umbilical artery HPSVDT can be defined as the period when waveform of umbilical artery descends from the peak down to the half. Since HPSVDT is related to placental compliance, HPSVDT of umbilical artery is inversely proportional to umbilical artery PI. That is, the more resistance of placental vascular area increases — namely a compliance decrease — the faster diastolic flow of umbilical artery decreases, which culminates in shortness of HPSVDT. The literature indicates that abnormal HPSVDT in the umbilical artery is strongly associated with increased vascular resistance and may serve as a parameter for predicting perinatal mortality in fetuses with FGR. Although the use of HPSVDT as a Doppler parameter dates back many years, it is still considered a relatively recent tool in the assessment of fetal well-being. In a study, the descending aorta flow deceleration time of children with the aorta coarctation was measured in the late 1990's, which showed, the longer the time stretched, the more the coarctation level increased [11].

In another study the HPSVDT was measured among 532 singleton pregnancies on 17th–41st weeks, 7 of whom had fetuses with bradycardia. It was seen that HPSVDT was not affected by fetal heart rate in the bradycardia group; thus, this parameter could be benefited to identify the well-being conditions in pregnant women with bradycardic fetuses. It also revealed that HPSVDT had a linear increase in 2nd and 3rd trimesters [4].

Another study examined the HPSVDT of umbilical artery among 266 singleton pregnancies of 24th–40th weeks with weights of fetuses of < 10 percentile. Eventually, it is found that 94% of the pregnant women with advanced or moderate retardation of growth had HPSVDT < 90 ms as well as such adverse indications as the need for prolonged newborn intensive care and postnatal mortalities. There was no fetus with HPSVDT < 70 ms, proving there is no association with intrauterine life [5]. Conversely, our study does not confirm any fetus as HPSVDT < 90 ms. Likewise, the mean HPSVDT was found to be 190.23 ± 13.37 ms in the control group though it was 120.37 ± 14.85 ms in the FGR group ($p < 0.001$). While the maximum was 142 ms (1 case), the minimum HPSVDT in the FGR group, emerged as 97 ms (in 2 cases). In the control group, though, the minimum HPSVDT was found to be 159 ms (1 case) whereas the maximum emerged as 212 ms (2 cases). A study illustrated perinatal mortality of 39 fetuses, 95% of which sprang as HPSVDT < 120 ms. Among those with HPSVDT < 90 and 23% among those with HPSVDT > 90 ($p < 0.01$), the perinatal mortality rate in the umbilical artery diastolic flow loss group was 51% [5].

Comparing the umbilical artery HPSVDT and other parameters within control and FGR groups, it was clear that within the FGR group, the Apgar scores increase when the umbilical HPSVDT increases, and the Apgar scores decrease when the umbilical HPSVDT decreases ($p < 0.01$).

The study also put umbilical cord blood pH decreased while umbilical artery HPSVDT decreased in terms of the correlation between the umbilical cord blood pH and umbilical artery HPSVDT variables ($p < 0.01$).

The study conducted by Bustos JC et al. [5] also recorded that lower neonatal weight is related to lower HPSVDT. Our study found comparable results in this regard. The relationship between neonatal weight and HPSVDT variables demonstrated that HPSVDT increased while the weight of the newborn increased ($p < 0.01$).

No statistical significance was observed in the control group between other variables (including Apgar 1st minute and 5th minute scores, cord blood pH, neonatal weight) and umbilical artery HPSVDT.

This study has certain limitations. Initially, gestational ages at the time of delivery are elder than those with FGR, and which, due to ethical reasons, could not be elaborately examined. Also, the sample size was limited to 60 (30 cases + 30 control) on account of missing data and loss in the follow-up. However, the strength of the study is that it is a prospective and case-control study.

CONCLUSIONS

In addition to NST, biophysical profile, practical biometric measurements, and Doppler practices, a new parameter, umbilical artery HPSVDT seems promising for perinatal prognosis evaluation among the pregnancies with FGR and follow-up treatment. The data collected in the study demonstrate umbilical artery HPSVDT can be useful among the pregnancies complicated with FGR for follow-up and identification of the delivery method. It can also serve as an extra parameter to the conventional MCA and umbilical artery Doppler in detecting perinatal prognosis. The Doppler parameter is supposed to be reinforced with more extensive data and research.

Article information and declarations

Data availability statement

The authors confirm that the data supporting the findings of this study are available within the article or its supplementary materials.

Ethics statement

This study was carried out in consensus with our university´s ethics guidelines. The ethics committee approval was obtained for this study. (No: 16-9/2).

Author contributions

OI — manuscript writing, data management, data analysis; IH — project development and administration; CG — data collection and analysis; ME — data management and analysis; HK — manuscript writing, review of the manuscript; FA — supervision, review of the manuscript.

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Conflict of interest

The authors declare that they have no conflict of interest.

Supplementary material

None.

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