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Original Article

Three Dimensional Power Doppler Ultrasound in Assessment of Placental Volume and Blood Flow and its Correlation with Severity of Pre-Eclampsia

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ABSTRACT

Background: Pre-eclampsia [PE] is a main reason for maternal and perinatal morbidities and mortalities. Three-dimensional power Doppler ultrasound [3DPD-US] methods nowadays give a noninvasive way of evaluating placental vascularization, flowing and vascularization-flowing indices. The specially designed VOCAL software, used in this technique, can calculate special indices and virtually reconstruct vascular tree within the given tissue volume.

Aim of the work: To evaluate the use of three-dimensional power Doppler [3DPD] ultrasound [US] in assessment of placental size and blood flow and its correlation with severity of pre-eclampsia.

Patients and Methods: This is a cross-sectional study which included 100 pregnant females with pre-eclampsia who had admitted to the Obstetrics and Gynecology Department of Bab-Alsheiria University Hospitals at the last antenatal care visit before delivery. The sample size was further allocated into 2 groups, each containing 50 cases, according to the severity of preeclampsia: the severe group and the mild group.

Results: There was a significant decrease in the placental volumes and blood flows among the studied groups. All three indices measuring vascularization index [VI], flow index [FI] and vascularization flow index [VFI] were revealed to be significantly higher in the mild group in comparison with the severe group.

Conclusion: 3DPD-US can give novel insights into valuation of placental volumes and blood flow and its correlation with severity of preeclampsia.

Keywords: Three dimensional power Doppler ultrasound; mild; severe; Preeclampsia.

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INTRODUCTION

Preeclampsia is the main cause of maternal and perinatal morbidities and mortalities described as the incidence of high blood pressure and substantial proteinuria in formerly healthy women on or after the 20th-wk of pregnancy. It happens in around 2–8% of all pregnant women [1].

Preeclampsia is defined according to ACOG guidelines as permanent BP 140-mmHg systolic and/or diastolic 90-mmHg happening after the 20th-wk of pregnancy and proteinuria > 0.3-g/day or entire protein/creatinine ratio > 0.3 [or 1+ proteinuria on urine dip stick examination on at least 2 occasions] [2].

Three-dimensional power Doppler ultrasound [3DPD-US] methods nowadays give a noninvasive way of evaluating placental vascularization and flow indices; vascularization, flowing and vascularization-flowing indices. 3DPD-US may describe interior placental vessel features like densities of vessels, branching, caliber variations, and tortuousness [3].

3D-US can give upgraded visualizations of embryonic anatomy in comparison to conventional two-dimensional [2D] US scanning. Subsequently, the introduction of 3DUS could simplify the new evaluation of the placenta, like surface-rendering scanning and size measurements. With the new developments in 3DPD-US, in addition to quantitative 3DPD histogram analysis, qualitative and quantitative evaluations of the vascularization and blood flow of the placenta have been possible [3].

The combinations of power and color Doppler sonography measures blood movements in very small vessels and allows calculations of their impact on the total perfusion of a given placenta size. These indices are computed via built-in algorithms in the VOCAL [Virtual Organ Computer-aided Analysis] package [3].

AIM OF THE WORK

To detect differences in placental condition regarding volume, vasculature, and blood flow between Mild and Severe Preeclampsia using 3DPD-US.

PATIENTS AND METHODS

This is a cross-sectional research which included 100 pregnant females who had presented and admitted to the Obstetrics and Gynecology Department of Bab Alseheiria University Hospitals at the last antenatal care visit before delivery. The study was done over a period of 6 months starting from Jan 2021 to June 2021. The sample size was

further allocated into 2 groups, every one containing 50 cases, according to the severity of preeclampsia: severe group and mild group.

Diagnostic criteria for mild preeclampsia: Preeclampsia was identified as high BP [140/90 or more] on at least 2 occasions, 6 hours apart, first recognized in this pregnancy, and detected after 20 weeks of gestation, together with proteinuria [> 300 mg in 24 hr urinary proteins, or albumin+1 or higher in complete urine analysis] [4].

Criteria of severity of preeclampsia: Severe preeclampsia was defined if any of the following severe features are present: systolic BP >160 mmHg or diastolic BP >110 mmHg, while the patient at bed rest, on two occasions, at least 4 hours apart [unless anti-hypertensive therapy is initiated before this time]. Other features of severity include: thrombocytopenia [platelet count < 100,000], abnormal liver function [elevated blood levels of liver transaminases to twice the normal concentration, severe persistent right upper quadrant or epigastric pain unresponsive to medication and not explained by alternative diagnoses, or both], new growth of renal insufficiency [elevated serum creatinine greater than 1.1 mg/dl, or doubling of serum creatinine in the non-existence of other reversible causes], new-onset cerebral or visual abnormalities, or pulmonary edema [4].

Inclusion criteria: Pregnant women in the 3rd trimester [> 26wks], singleton pregnancy with normal fetal morphology and diagnosed with pre-eclampsia were included.

Exclusion criteria: Fetal chromosomal anomalies and deformities, placental irregularities [placental bipartite or velamentous insertion], placenta previa and abnormally invasive placenta, umbilical anomalies [single umbilical artery, vasa previa], other complications accompanying with gestation [gestational diabetes, intra-hepatic cholestasis and anemia], systemic vascular or auto-immune diseases [systemic lupus erythematosus and rheumatoid arthritis], ruptures of the amniotic membranes, women taking vasoactive medications and self-reported drug, alcohol, or nicotine abuse.

The study groups were evaluated for full history of obstetric and gynecological history. Physical examination included vital signs and abdominal examination for determination of fetal lie, position and size. Laboratory investigations included complete blood picture with platelet count, liver enzymes, serum creatinine levels and 24-hour urine proteins.

Ethical considerations

Verbal and written informed consents were taken before the start of the study. The presented study was approved by the Research and Ethical committee, Faculty of Medicine-Al-Azhar University.

Statistical analysis

Data were fed to the computer and analyzed using IBM SPSS software package version 20.0. [Armonk, NY: IBM Corp]. Qualitative data were described using number and percent. The Kolmogorov-Smirnov test was used to verify the normality of distribution. Quantitative data were described using range [minimum and maximum], mean and standard deviation. Chi-square test was used for categorical variables, to compare between different groups, Student t-test was used for normally quantitative variables, to compare between two studied groups, and Mann Whitney test was used for abnormally quantitative variables, to compare between two studied groups. Significance of the obtained results was judged at the 5% level.

RESULTS

Patients were classified into 2 groups; group (A): included 50 patients with mild preeclampsia, and group (B): included 50 patients with severe preeclampsia.

Patients with severe preeclampsia had significantly lower gestational age [$P=0.034$], higher systolic blood pressure [170.70 ± 5.697 vs. 150.50 ± 5.825 ; $P=0.037$]. No other significant difference regarding maternal age, weight height, BMI and diastolic blood pressure [Table 1].

There was significant elevation of ALT, creatinine and 24h urinary proteins among patients with severe preeclampsia [Table 2].

On Comparison between two groups as regard to patients' vascularization index, In the Flow index, vascularization flow index; there was statically significant difference among the studied groups [Table 3].

Table [1]: Comparing between both groups regarding demographic and clinical characteristics

		Group [A] [n=50]	Group [B] [n=50]	Test	P-Value
Gestational age	Min-Max	32-39	29-38	u=633.00	0.034
	Mean \pm SD	36.40 \pm 3.541	34.48 \pm 3.683		
Maternal age	Min-Max	21-38	22-40	u=1014.50	0.103
	Mean \pm SD	26.12 \pm 4.003	28.08 \pm 3.440		
Weight	Min-Max	62-95	61-100	u=1245.00	0.975
	Mean \pm SD	79.22 \pm 10.432	79.34 \pm 10.205		
Height	Min-Max	153-180	152-181	u=1116.50	0.357
	Mean \pm SD	167.42 \pm 8.355	165.82 \pm 8.665		
Body mass index [BMI]	Min-Max	19.79-37.21	20.52-38.22	t=0.662	0.509
	Mean \pm SD	28.45 \pm 4.576	29.06 \pm 4.614		
Systolic Blood Pressure	Min-Max	140-160	150-200	u=789.00	0.037
	Mean \pm SD	150.50 \pm 5.825	170.70 \pm 5.697		
Diastolic Blood Pressure	Min-Max	90-100	90-130	u=1038.00	0.075
	Mean \pm SD	96.30 \pm 3.164	110.30 \pm 3.066		

u: Mann-Whitney test; t: Student T-test

Table [2]: Comparing between both groups regarding laboratory data

		Group [A] [n=50]	Group [B] [n=50]	Test	P value
AST	Min-Max	25-65	72-360	t=0.106	0.116
	Mean \pm SD	45.84 \pm 11.767	110.58 \pm 12.738		
ALT	Min-Max	32-51	63-489	u=941.50	0.033*
	Mean \pm SD	41.10 \pm 5.853	194.58 \pm 5.485		
Creatinine	Min-Max	0.80-1.30	0.70-3	u=1137.00	0.043
	Mean \pm SD	1.22 \pm 0.57	1.36 \pm 0.328		
24 hours urine proteins	Min-Max	305-880	340-6000	u=1130.50	0.039
	Mean \pm SD	422.40 \pm 56.365	1952.32 \pm 54.586		

u: Mann-Whitney test; t: Student T-test

Table [3]: Comparison between the two groups as regard to patients' 3P Doppler Ultrasound parameters

		Group [A] [n=50]	Group [B] [n=50]	Test	P-Value
Placental volume	Min-Max	180-540	116-313	u=569.	<0.001*
	Mean ± SD	268.88±82.923	198.56±45.166		
Vascularization index [VI]	Min-Max	8-31	1-13	u=144.5	<0.001*
	Mean ± SD	16.96±5.57	8.52±2.71		
Flow Index [FI]	Min-Max	20-54	7-46	t=6.438	<0.001*
	Mean ± SD	36.14±7.401	26.04±8.26		
Vascularization flow index [VFI]	Min-Max	2-8	1-4	u =357	<0.001*
	Mean ± SD	4.48±1.47	2.68±0.74		

DISCUSSION

Quantitative 3DPD analysis was utilized to evaluate placental perfusions and vascularization indices that mirror both utero-placental and fetoplacental blood perfusions. Direct investigations of the perfusion of in vivo placentae have been feasible. Even every small blood motion within the studied size may be recorded by a mixture of power and color Doppler sonography reflected by these indices [3].

The three indices or parameters assessing placental perfusion and vascularization are the vascularization index [VI], which is the determination of the percentage of vascularized tissues. The Vascularization flow index [VFI] measures the relative amount of moving blood in the sampled tissues. FI [Flow index] measures the amplitude of the blood movements in the sampled placental site [3].

De Paula *et al.* [6] demonstrated that all placental vascular indices assessed via 3DPD presented a persistent distribution during pregnancy in spite of the rise in placenta volume in accordance to pregnancy age. In the present study, we revealed a significant association [P-value 0.05] between gestational age and severity of preeclampsia and placental volume. In another study, by Moran *et al.* [7], there was no correlation between size and gestational age among pre-eclampsia patients. In the same study, VI and VFI aren't impacted by pregnancy, but FI was detected to rise with pregnancy age. All 3 indices were less than standard values in-between 24-and 30-wks. This is in accordance with the present work as the three indices were found to be significantly lower than the reference limit, although pregnancy was in the third trimester in both non-severe and severe groups. This placenta volume could only be a prognosticator of the severity of preeclampsia.

In contrast to our studies, Rizzo *et al.* [8] performed prospective observational research on 32-pregnancies at the 1st trimester of gestation to evaluate placental volume. They found a non-significant change in the placenta volume when compared to the reference limit. A change in the number of preeclampsia patients in the studied groups could play a role in the different results.

The present work was performed to determine the placenta vascularization in the third trimester of gestation and its connection with pre-eclampsia severity. All three indices measures VI, FI and VFI were revealed to be high significantly in the non-severe group in comparison with the severe group.

As in the present study, Yuan *et al.* [9] stated that all 3DPD indices had a significant relationship with gestation age, and FI, VI, and VFI of the placenta were significantly lower in the severe preeclampsia group in comparison with the ordinary group. Furthermore, in accordance with our results, they stated that there was a significant decrease in VI and VFI vascular indices comparing the non-severe and severe groups of preeclampsia. In comparison with normotensive cases, cases with severe pre-eclampsia had a significant decrease in placenta VI & VFI. There is marked similarity with the results of the present work as comparison of VI in the non-severe group to normal reference value showed a non-significant decrease in our work.

Thus, according to Yuan *et al.* [9], intra-placental vascularization was worse in females with severe pre-eclampsia, while damage to placenta vessels may be relatively mild in non-severe preeclampsia.

The findings of the present work were in agreement with Chen *et al.* [3], who stated that all three indices were significantly lower in severe pre-eclamptic placenta in comparison with control and that the severity of pre-eclampsia couldn't be expected by vascular indices.

Mercé *et al.* [10] found an increase in VI, FI and VFI with a positive correlation with gestational age, but this author identified only a portion of the placenta with the maximum density of vessels, a technique called vascular placental biopsy.

These results are in contrast to Guiot *et al.* [11], who found a decrease in VI, FI and VFI. This could be due to the fact that they calculated vascular indices in five constant regions of the placenta.

In contrast to the present study, the results of Suranyi *et al.* [12], reported lower VI in gestations complicated by preeclampsia in comparison with controls, though the change was non-significant.

Our objective was to examine volume and placental vascularization in both non-severe and severe groups of preeclampsia in the third trimester. A decrease in measured parameters in both groups was seen, which can help in detection of preeclampsia. Therefore, we may decide about managing and monitoring strategies.

3DPD sonography can give new visions into placenta pathophysiology. Additional research is desired to determine its accuracy when utilized in clinical practices as a supernumerary or an assistant to umbilical artery Doppler. Also, possible correlation with clinical biomarkers during preeclampsia such as soluble fms-like tyrosine kinase 1 [sFlt-1] or placenta growing factor [PIGF] could help in management. In spite of multiple publications and journal submissions using 3DPD, the consistency and reproducibility of parameters are still suspected. Fixed reference values for prognosis and management are still lacking.

CONCLUSION

3DPD-US can give novel insights into evaluation of placental volumes and blood flow and its correlation with severity of preeclampsia. Additional research is desired to confirm its accuracy when utilized in clinical practices. In this study, a comparison between mild and severe pre-eclamptic patients as regards placental volume showed that there was a significant decrease in the placenta size among the studied groups. We revealed a non-significant association [P-value > 0.05] between gestational age and the volume of the placenta regarding the severity of preeclampsia. All three indices measuring VI, FI and VFI were revealed to be significantly higher in the mild group in comparison with the severe group.

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None

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