DOPPLER EVALUATION OF FETOPLACENTAL AND UTEROPLACENTAL CIRCULATION OUTCOMES IN WOMEN WITH PRE-ECLAMPSIA: COMPARISON AND CORRELATION BETWEEN DIFFERENT DOPPLER PARAMETERS

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ABSTRACT

Background: Preeclampsia (PE) affects between 5% and 8% of all pregnancies and is one of the leading cause of maternal mortality in underdeveloped countries.PE is characterized by the new onset of high blood pressure and proteinuria with or without body swelling that occurs after 20 weeks of gestation and lasts up to 6 weeks after labor. The pathophysiology of PE is based on the incapability of the trophoblast to invade the myometrium properly causing improper remodeling of spiral arteries resulting in fetoplacental insufficiency and this can be detected by using Doppler ultrasound.

Objective: To compare and correlate among cerebroplacental ratio (CPR), uterine artery, umbilical artery, and middle cerebral artery (MCA) parameters outcomes in established cases of pre-eclampsia

Patients and methods: A total 36 cases of pregnant women who were diagnosed clinically and by laboratory investigation as preeclampsia were included in this study in cross-sectional study to evaluate fetoplacental and uteroplacental circulation using Doppler parameters such as pulsatility index (PI) and cerebroplacental ratio.

Results: There was a strong correlation between the cerebroplacental ratio and Middle cerebral artery PI (p-value =0.0006); however, a minimum positive correlation was found between CPR and umbilical artery (UmA) and uterine artery (UTA) p=0.0274 and 0.0244 respectively

Conclusion: A positive correlation found between CPR PI and MCA, UTA, UmA pulsatility indices; therefore, we conclude that they can be used as complementary to each other in we conclude that they can be used as complementary to each other for identifying high-risk pregnancies, early detection of fetal compromise and consequently optimizing the timing of intervention.

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Keywords: Doppler Parameters, Kurd, Iraq, pre-eclampsia.

Preeclampsia is a multisystem condition that is caused by an improper placentation that affects the health of both the mother and the fetus during pregnancy. Diagnosis of preeclampsia according to the International Society Study of Hypertension in pregnancy require the presence of systolic BP ≥ 140 mm Hg and/or diastolic BP ≥ 90 mmHg on two separate occasions in women whose blood pressure had previously been in the standard range as well as proteinuria (dipstick test positive)[1] .'Physiological transformation of the placenta ' refers to a process of placentation that occurs in normal pregnancy when spiral arteries are invaded by trophoblastic cells and turned into uteroplacental arteries which become

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tortuous and dilated. It has been observed that trophoblastic invasion occurs in two stages: the first wave converts the decidual segments of the spiral arteries in the first trimester, and the second wave converts the myometrial segments in the second trimester[2,3]. The pathophysiology of preeclampsia is predicated on the trophoblast's inability to effectively infiltrate the myometrium, resulting in an inadequate remodeling of spiral arteries which results in diminished uteroplacental perfusion[4]. Preeclampsia is a significant cause of poor pregnancy outcomes[5]. In early pregnancy the uterine arteries are highly pulsatile and have a high systolic flow with a low diastolic flow with the existence of a diastolic notch[6]. The resistance is dropped gradually as the pregnancy advance due to trophoblastic invasion of the myometrium, the persistence of high resistance uterine artery leads to preeclampsia and intrauterine growth retardation. In an abnormal functioning placenta such as in PE the umbilical artery resistance increases gradually and eventually reverses[7]. Dilatation of the cerebral arteries occur in fetal persistent hypoxia to supply the brain with blood (blood brain sparing) leading to changes of middle cerebral artery from a high resistance to a low resistance these changes can be detected using different Doppler parameters[8,4]. One of the well-known parameter used for the detection of the brain-sparing effect is cerebroplacental ratio since the changes in the CPR precedes that of fetal MCA and umbilical arteries alone. When compared to MCA or UmA Doppler alone, a low cerebroplacental ratio suggests redistribution of cardiac output to the cerebral circulation and has been demonstrated to enhance accuracy in predicting adverse outcome[9,10]. As a result, early identification and thorough prenatal surveillance are essential to enhance the perinatal outcomes, which is accomplished by noninvasively evaluating the fetoplacental and uteroplacental circulation by Doppler ultrasound. Doppler ultrasonography is a noninvasive tool for studying blood circulation by detecting changes in the frequency of reflected sound. Since 1977 doppler ultrasonography has been used in obstetrics to examine the fetoplacental (umbilical) circulation, and since the 1980s, it has been used to study the uteroplacental (uterine) circulation and fetal circulation)[11]. This technique has recently become an essential tool for detecting high-risk pregnancies, early identification of fetal compromise and subsequently proper management[12]. The uterine artery reflects the mother’s vascular status via the pulsatility and resistance index (PI and RI), as well as the presence of an early diastolic notch (N)[13]. However, the middle cerebral artery and umbilical artery together reflects fetal status via pulsatility and resistance index (PI and RI) as well as Cerebroplacental ratio. Women proved to be diagnosed clinically as preeclampsia were enrolled in this study, their uterine artery, umbilical artery, and fetal middle cerebral artery were examined using pulsatility index and CPR to compare and correlate changes between them. PI values above the 95th percentile standardized for the gestational age were considered abnormal for the uterine and umbilical arteries, and below the 5th percentile was considered abnormal for the middle cerebral artery[14,12].

The cut off values of Doppler velocimetry between 28th - 40th weeks of gestation are as follow[14].

Uterine artery PI: 1.2

Umbilical artery PI: 1.2

Middle cerebral artery PI: 1.3

CPR: 1.08

PATIENTS AND METHODS

DESIGN OF THE STUDY:

This cross-sectional study is started after receiving the official letter of approval from the ethical committee to evaluate fetoplacental and uteroplacental circulation in pregnant women between (28-39 weeks) of gestation who proved clinically and by laboratory investigation as preeclampsia using fetal middle cerebral artery, umbilical artery and uterine artery Doppler parameters including PI and CPR.

ELIGIBILITY:

This study was approved by local health ethics committee in Duhok directorate, this study did not carry any harm or side effects to the patients.

INCLUSION CRITERIA:

Ages of mother 18 - 40 years

(28 - 40 weeks of gestation)

High BP + Proteinuria (at least 1+ dipstick)

EXCLUSION CRITERIA:

Pregnant women with multiple gestation, oligohydramnios, pregnancies with congenital fetal anomalies, and those who have other medical condition (such as Diabetes Mellitus, chronic hypertension, and renal disease) were excluded from the study.

MATERIAL AND MACHINES

All examinations were performed at Duhok hospital for obstetrics & gynecology using 3.5 MHZ convex transducer with Philips (HD 11XE) and Siemens (ACUSON X 300) ultrasound machines, all cases were subjected to the following:

A complete history was obtained (personal, past menstrual, obstetric, and past medical) in addition to laboratory investigation.

By B- mode ultrasound fetal biometry assessment was done.

Color Doppler used to identify vessels of interest, presence of flow, direction, and velocity of flow

By spectral Doppler ultrasound, an examination of uterine artery has been done at the site where crosses over external iliac vessels, both uterine arteries were scanned to prevent biases due to lateral placental implantation, their PIs was taken and the average were recorded followed by examination of umbilical artery from free floating loop and it's PI were recorded. Lastly fetal one middle cerebral artery (which was examined within 2mm of its origin from the Circle of Willis) was examined for PI.

At the same time CPR was calculated by dividing the Doppler pulsatility index of the MCA by the UmA PI.

Although in obstetric Doppler ultrasound angle independent indices are used however Optimization of the machine to get a correct Doppler wave form was needed by putting Sample volume at center of vessels, adjustment of PRF knob and baseline to get optimum wave.

The abnormalities that have been considered including PI above 95th percentile standardized for the gestational age was considered abnormal for uterine artery and umbilical artery while below the 5th percentile was considered abnormal for the middle cerebral artery8, and 1.08 considered as cut off value for CPR15,16.

STATISTICAL ANALYSES

The general characteristics of women were presented in mean and Standard deviation for nominal variables and number (percentage) for categorical variables. The correlation of CRP with average UTA, UmA and MCA PI were done by bivariate regression, The significant level of difference was determined in a p-value of less than 0.05.

RESULTS

In the total 36 cases were included in this study. The age of participant ranged between 18-39 years and mean was 29.08 ± 4.74 years, and 17 (47.22%) of patients were primigravida. The mean gestational age was 33.22 ±3.70 weeks, ranged between 28-39 weeks. Table 1.

Table 1 General Characteristics of the study population

Patient's characteristic (n=36)		Mean ± CD	
Age (18 - 39)		29.08 ± 4.74	
Gestational age (28 - 39)		33.2 ±3.69	
		Number	%
Gravidity	Primigravida	17	47.22%
	Multigravida	19	52.78%

Cerebroplacental ratio PI had mean value of 1.23 ±0.63, ranging between 0.25 - 3.1, CPR PI was abnormal in 15 cases (41.6%) Table 2.

Table 2. Descriptive statistics of CPR in the study population

CPR PI	Range	0.25-3.1
	Mean ±SD	1.23 ±0.63
	Measures	No. (%)
	Normal >1.08	21 (58.3%)
	Abnormal <1.08	15 (41.6%)

Correlation between CPR and uterine artery, umbilical artery, and MCA pulsatility indices: There was a strong correlation between cerebroplacental ratio and middle cerebral artery PI (p=0.0006); however, week positive correlation was observed for cerebroplacental ratio and Umbilical artery and average uterine artery PI (p=0.0274 and 0.0244) respectively. Table 3 and figure1.

Table 3. Correlation between CPR and UTA.,UmA. MCA Bivariate regression was performed for statistical analyses

Arteries PI	CP ratio PI			
	r- value	Lower 95%	Upper 95%	p-value
Average uterine artery PI	-0.41013	-0.67122	-0.05851	0.0244
Umbilical artery PI	-0.42417	-0.69255	-0.05264	0.0274
Middle cerebral artery PI	0.548582	0.263508	0.745535	0.0006

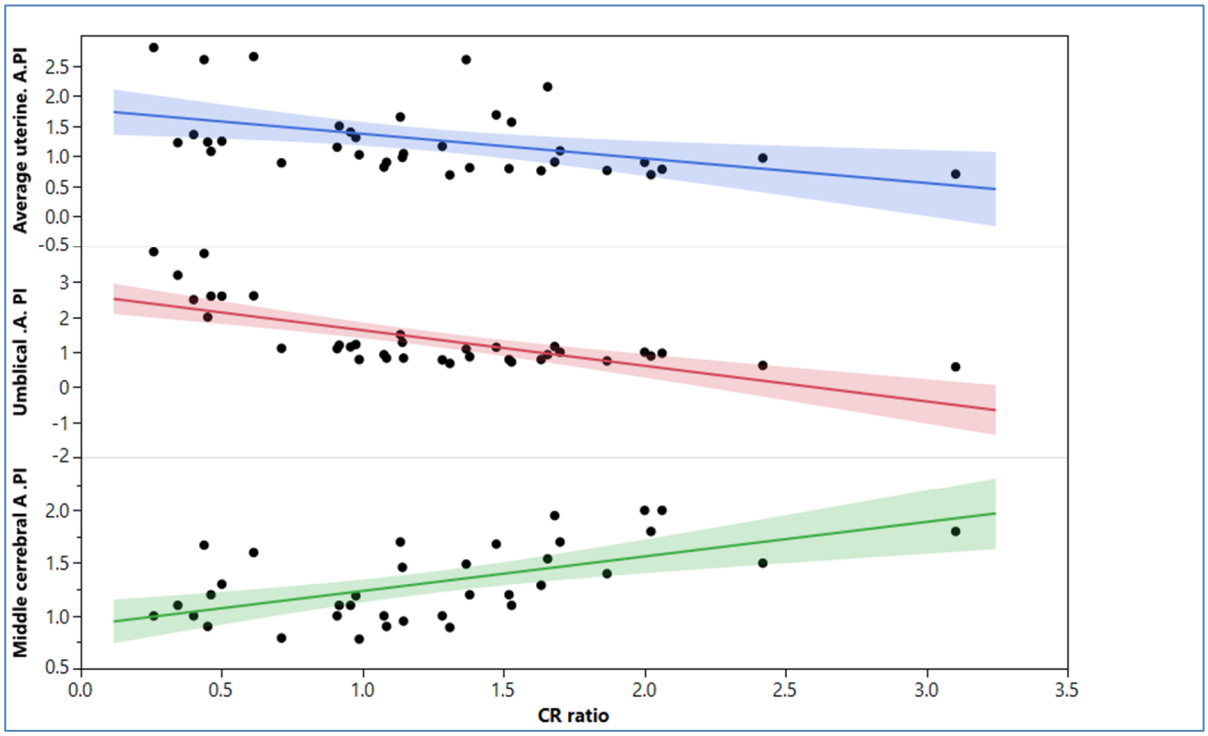

Figure 1 Correlation between CPR and UTA, UmA, MCA pulsatility indices

DISCUSSION:

Doppler ultrasound provides a non-invasive method in evaluation of fetal and maternal circulation during pregnancy by giving information about state of the placenta perfusion and fetal well-being using different Doppler indices. Comparisons between this study and other comparable studies may be difficult because of differences in methodology, sample size, and indices cutoff values. We choose pulsatility index to do a correlation between CPR with the other arteries because PI is more important doppler parameter in reflecting the state of distal organ perfusion and many studies previously done found that pulsatility index in CPR has more sensitivity in predicting pregnancy outcome than the other parameters 9,17. Thirty-six pregnant women between 28 and 39 wks. of gestation who had been diagnosed with preeclampsia were involved this study and examined with Doppler ultrasound. The purpose of the study was to evaluate the comparison and correlation between the cerebroplacental ratio and uterine artery, umbilical artery, and MCA pulsatility indices in patients who have preeclampsia. Although most studies on uterine artery during pregnancy were conducted in the first and second trimesters and abnormalities in UTA indices are widely used to predict the extent of trophoblast invasion and function, as well as the likelihood of placental diseases such as preeclampsia and growth restriction of fetus. However, there are few studies established to evaluate its changes in women with preeclampsia in the third trimester, they found that there is an association between abnormal UTA Doppler indices in the third trimester and poor pregnancy outcome. In this study it is found that UTA indices are more affected than that of umbilical artery. Similarly, a study done by Gudnasonet.al. found that uterine artery changes are more frequent than umbilical artery18. In this cross-sectional study, it was found that cerebroplacental ratio PI and the middle cerebral artery PI are strongly correlated (p-0.0006). In agreement with these results; a

study done Sharbaf et.al. in 2018 who found that there was as significant correlation between CPR and MCA PI. Furthermore, they did comparison between Umbilical artery and MCA they conclude that MCA pulsatility index is more sensitive than umbilical artery pulsatility index in prediction of outcome, but middle cerebral artery/ umbilical artery ratio showed more specificity in prediction of perinatal outcome19. In our study a minimum positive correlation found between CPR and umbilical artery and uterine artery. In contrary, Saber et.al. did a cross-sectional study on 100 cases, and they found strong correlation between CPR and UmA. PI 20, and in another study done by Srikumar et.al. in 2017, they assessed the correlation between CPR and umbilical and middle cerebral artery PI on 200 cases between 19-40 weeks, and they found that CPR showed a minimal positive correlation with MCA PI and a strong negative correlation with Umbilical PI 21. This difference might be due to difference in statistics and number of cases. In 2022 a study conducted by Moawad et.al. on correlation between the cerebroplacental ratio and umbilical artery Doppler, they found that CPR had a high sensitivity and specificity in comparison to umbilical artery 22. Similarly, several authors such as Shahinaj et.al. Patil et al and Smitha et.al. concluded that in correlation to MCA and umbilical artery; CPR is best predictor to pregnancy out in preeclampsia than middle cerebral artery and umbilical artery Doppler indices alone 23,10,24. Regarding CPR and UTA, Khalil et al.found associations between UTA Doppler indices, and CPR, they suggest that low CPR (a fetal hypoxemic response) is related to impaired placental perfusion, placental insufficiency, and poor fetal growth25.

CONCLUSION

A positive correlation found between CPR PI and MCA, UTA, UmA pulsatility indices; therefore, we conclude that they can be used as complementary to each other for identifying high-risk pregnancies, early detection of fetal compromise and consequently optimizing the timing of intervention, further research is warranted to compare CPR outcome with fetal birth weight.

STRENGTH AND LIMITATIONS OF THE STUDY

The strength of the study is that few previous studies are available which correlate between UTA, UmA and MCA and CPR in third trimester in established PE.

Limitation was the small sample size.

CONFLICT OF INTEREST

There are no conflicts of interest.

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پوختە

هەلسەنگاندنا دوبلەرێ بو خۆلا کورپەلەی و مالبچویکی لنك ئافرەتێن تووشبووی ب ژەهربوونا د دووگیانیێدا: بەراوردکرن و هە قبەندی دناڤبەرا پیڤەرێن دوبلەرێ یێن جیاوازدا

پێشەکی و ئارمانج: ژەهربوون د دووگیانیێدا تووشی دناڤبەرا (5 %) و (8 %) دبیت ژ هەمی حالەتێن دووگیان دا کو ئێکە ژ ئە گەرێن سەرەکی یێن گیان ژ دەستدانا دایکان ل وەلاتێن جیاوازدا. تایبەتمەندیا ژەهربوونێ د دووگیانیێدا دیاربوونەکا نوییە یا بلندبوونا پەستانا خوینێ و پرۆتینی د ناڤ میزێَ دا دگەل وەرمتنا لەشی یان بێی وێ کو پشتی (20) حەفتیان ژ دووگیانیێ پەیدا دبیت و هەتا (6) هەیڤان پشتی مەهیکێ بەردەوام دبیت. فیزیولوژیا نەخۆشیێ یا ژەهربوونێ د د دووگیانیێدا پشت بەستنێ ل سەر نەشیانا ئورمیا خوراکدانێ دکەت د داگیرکرنا بهێزبوونا مالبجویکی ب شێوەکێ دروست، ئەڤەژی دبیتە ئەگەرێ پێك نینانەکا نەگونجای بو خوینبەرێن لووپێچی و دبیتە ئەگەرێ زێدەبوونا بەرگریا لوولەکێن خوینێ د مالبجویکیدا. جێدبیت ئەڤ جەندە بهێتە دیارکرن د بکارئینانا پێلێن سەر دەنگیدا (دوبلەر).

ئارمانج: بەراوردکرن و پێکڤەگرێدان دناڤبەرا نیشاندەرێن لێدانا مێشکی خوینبەرا مالبجویکی و خوینبەرا نافکێ و خوینبەرا مێشکی یێ ناڤەند د حالەتێن دووپاتکریدا ژ ژەهربوونێ د دووگیانیێدا.

نەخۆش و رێك: نێزیکی (36) حالەتێن تووشبووی ب ژەهربوونا دووگیانێ کەتنە بەر ڤێ ڤەکولینێ و ل نەخۆشخانا زارۆکبوونێ ل دهۆکێ ئامادەبوون. د ڤەکولینەکا بر ِگەییدا بو هەلسەنگاندنا زڤرۆکا خوینێ یا کورپەلەی و مالبجویکی بکارئینانا پیڤەرێن دوبلەر یێن جیاواز (نیشاندەرێ بەرگریێ و نیشاندەرێ لێَدانێ و ڤەژاندنا دلی یا سیهێ زێدەباری دەرزا فرەهبوونێ).

ئەنجام: هەڤبەندەکا ئەرێنی هەبوو دناڤبەرا رێژا خوینبەرا مێشکی و نیشاندەرێ لێدانێ یا خوینبەرا مێشکی یا ناڤەند (بەهایێ جێبوونێ = 0,0006) دگەل وێ جەندێ کێمتر هەڤبەندی هاتە دیتن دناڤبەرا ڤەژاندنا دلی یا سیهێ و خوینبەرا نافکێ و خوینبەرا مالبجویکی (P = 0.0274 و 0.0244 لدویڤ ئێك).

دەرئە نجام: پەیوەندیەکا ئەرێنی هاتە دیتن دناڤبەرا نیشاندەرێ لێدانێ و ڤەژاندنا دلی یا سیهێ و نیشاندەرێن لێدانێ یێن خوینبەرا مێشکی یا ناڤەند و خوینبەرا مالبجویکی و خوینبەرا نافکێ، ژبەر وێ جەندێ بومە دیار دبیت کو جێدبیت بهێنە بکارئینان وەك تەمامکەرێن ئێك دوو بو پێشبینیکرنا ئەنجامێن دووگیانیا نەرێنی د ژەهربوونێ د دووگیانیێدا و د سێیەکا سێیێ ژ دووگیانێ.

الخلاصة

تقييم فحص دوبلر (التخطيط فوق الصوتى) للدورة الجنينية المشيمية والدورة الرحمية المشيمية في النساء المصابات بتسمم ما قبل الولادة: المقارنة والارتباط بين مقايس الدوبلر المختلفة

الخلفية والأهداف: تصيب تسمم ما قبل الحمل ما بين (5%) و(8%) من جميع حالات الحمل وهي احد الأسباب الرئيسية لوفيات الامهات في البلدان المتخلفة. يتميز تسمم الحمل بالظهور الجديد لارتفاع ضغط الدم وزلال البول مع تورم الجسم او بدونه الذي يحدث بعد (20) اسبوعاً من الحمل ويستمر حتى (6) اسابيع بعد المخاض. تعتمد الفيزيولوجيا المرضية لتسمم ما قبل الحمل على عدم قدرة الارومة المغذية على غزو عضلة الرحم بشكل صحيح مما يؤدي إلى اعادة تشكيل غير مناسب للشرايين الحلزونية، مما يؤدي الى زيادة مقاومة الاوعية الدموية في المشيمة، ويمكن اكتشاف ذلك باستخدام الموجات فوق الصوتية دوبلر.

الهدف: المقارنة والربط بين مؤشرات النبض الدماغي والشريان الرحمي والشريان السري والشريان الدماغي الاوسط في الحالات المؤكدة من تسمم الحمل.

المرضى وطرق البحث: تم تضمين اجمالي (36) حالة مصابة بتسمم الحمل في هذه الدراسة الذين حضروا مستشفى الولادة في دهوك في دراسة مقطعية لتقييم الدورة الدموية الجنينية والرحمية المشيمية باستخدام معايير الدوبلر المختلفة (مؤشر المقاومة ومؤشر النبض والانعاش القلبي الرئوي بالاضافة إلى الشق الانبساطي ن).

النتائج: كان هناك ترابط ايجابي عالى بين نسبة الشريان الدماغي ومؤشر النبض للشريان الدماغي الاوسط (قيمة الاحتمال p = 0.0006). ومع ذلك، وجد الترابط الاجابي الادنى بين الإنعاش القلبي الرئوي والشريان السري والشريان الرحمي (p = 0.0274) و(0.0244) على التوالي.

الاستنتاجات: وجدت علاقة ايجابية بين مؤشر النبض للانعاش القلبي الرئوي ومؤشرات النبض للشريان الدماغي الاوسط والشريان الرحمي والشريان السري؛ لذلك نستنتج انه يمكن استخدامها كمكملات لبعضها البعض في التنبؤ بنتائج الحمل السلبية في تسمم الحمل ما قبل الولادة في الثلث الثالث من الحمل.