Doppler Ultrasonography of Foetal Middle Cerebral and Umbilical Arteries in High Risk Pregnancy

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Abstract

Background: Foetal hypoxemia is associated with increased impedance to flow in the umbilical artery (UA) and decreased impedance in the fetal middle cerebral artery (MCA).

Aim of Study: To evaluate Doppler of foetal Middle cerebral (MCA) and Umbilical (UMA) arteries in high risk pregnancies.

Patients and Methods: This prospective cross-sectional study was carried on 100 patients at Menoufia university hospital in the period from March 2017 to Febraury 2018 using a 2-5MHz transabdominal probe (GE LOGIC p5 and GE LOGIC p7). The study including two groups, group (A) High risk group: Including 50 patients with pregnancy above 27 weeks presenting with high risk pregnancy, and group (B) control group: Including 50 patients with normal pregnancy above 27 weeks, Doppler examination for both MCA and UMA was done.

Results: Out of the fifty pregnant women in Group A, there were 18 cases with abnormal UMA Doppler, 14 cases with abnormal MCA Doppler indices and 10 cases with abnormal cerbroplacental (CPR). For estimating the association between high risk pregnancy and resistive index (RI) and pulsatility index (PI) of both UMA and MCA for predicting foetal outcome, RI of UMA showed sensitivity and specificity of 70% and 60% and accuracy of 63% and MCA RI showed sensitivity of 74%, specificity of 48% and accuracy of 61%.

Conclusion: Doppler ultrasonography of foetal middle cerebral and umbilical arteries plays important role in high risk pregnancies and predicting foetal outcome.

Key Words: Doppler – Foetal outcome – High risk pregnancy – Middle cerebral – Umbilical.

Introduction

THE introduction of colour Doppler velocimetry to obstetrics offers a non invasive method for assessing the foetal and uteroplacental circulation. Umbilical artery Doppler waveform was first examined as mean of monitoring foetal compromise. It is one of the most frequently used non invasive tests of foetal well-being [1].

Technological advances in the equipment allowed the study of other foetal vessels such as middle cerebral artery (MCA) and renal arteries, improving detection of disturbances in fetus well-being. By monitoring the Doppler changes, it is possible to track the foetal-placental cell changes, which give idea about etiology for several foetal co-morbidities [2].

Abnormal placental perfusion in the maternal compartment results in increased blood flow resistance in the uterine artery flow velocity in waveform. Abnormal perfusion of foetal blood flow associated with decreased umbilical artery end-diastolic velocity proportional to the degree of flow impairment. Abnormal oxygen diffusion across the villous membrane is associated with a decrease in middle cerebral artery blood flow resistance [2].

The ratio of the middle cerebral artery pulsatility index (MCA PI) over the umbilical artery pulsatility index (UA PI) is named as the cerebro-placental ratio (CPR) and is reflective of the severity of cerebral redistribution. However, the CPR changes over gestation and is proportionate to foetal growth [3].

The third-trimester ultrasound exam in high-risk pregnancies, i.e. borderline amniotic fluid volume, pre-eclampsia, intrauterine growth retardation (IUGR), diabetic mother, placental abnormalities, etc, is necessary to predict adverse perinatal outcomes [4,5]. Intrauterine growth restriction (IUGR) is an important clinical problem, being

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the most important cause of perinatal morbidity and mortality [6] . Abnormal Doppler findings in the third trimester are usually associated with adverse perinatal outcome [7,8].

The aim of this work was to assess foetal umbilical and middle cerebral artery Doppler for predicting foetal outcome in high risk pregnancy.

Patients and Methods

This prospective cross -sectional study and was carried on 100 patients at child bearing period at Menoufia university hospital (department of Radiology) and Desouq Hospital Government of Kafer El-Sheikh in the period from March 2017 to Februaray 2018 using a 2-5MHz transabdominal probe (GE LOGIC p5, Japan and GE LOGIC p7, Japan). The study including two groups, group (A) High risk group including 50 patients with pregnancy above 27 weeks presenting with high risk pregnancy e.g pre-eclampsia, diabetes of pregnancy, placental abnormalities, IUGR and oligo or poly-hydraminous and group (B) control group including 50 patients with normal pregnancy above 27 weeks without risk factors e.g hypertension, IUGR, etc.

Inclusion criteria: For high risk group (group A): Patients with pregnancy above 27 weeks with high risk pregnancy e.g pre-eclampsia, diabetes of pregnancy, placental abnormalities, congenital foetal anomalies, foetal anaemia and twin pregnancy. For control group (group B): Patients with pregnancy above 27 weeks with normal pregnancy without risk factors e,g hypertension, diabetes mellitus (DM) and vaginal bleeding etc.

Exclusion criteria: For high risk group (group A): (1) Patients with pregnancy below 27 weeks. (2) Intrauterine fetal death. For control group (group B): (1) patients with pregnancy below 27 weeks. (2) Patients with pregnancy with risk factor e.g pre-eclampsia, DM, placental abnormalities, oligohydraminous, congenital fetal anomalies, etc.

Ethical considerations: Informed written consent was obtained from all patients in the study with explanation of the examination technique to all patients. The study was approved by Ethical Committee of Menoufia University.

Technique and scanning:
All included patients were informed regarding to procedure and were submitted to complete history taking including personal history of mother, full obstetric history, past history of medical prob-

lems, history of dug intake and history of present pregnancy including gestational age by last menstrual period (LMP) and any medical problems or drug taking during pregnancy.

General examination of pregnant patients was done including: Weight, colour of the face and measuring of blood pressure. Other laboratory investigations e.g fasting blood sugar, albumin in urine and complete blood count.

Obstetric ultrasound examination using a 2-5MHz transabdominal probe (GE LOGIC p5, Japan and GE LOGIC p7, Japan) with the patient in a semirecumbant position to assess: Viability of pregnancy, Gestational age (GA) of fetus, foetal weight, major fetal abnormalities, Liquor amount and placental abnormalities.

Colour Doppler examination of both foetal middle cerebral and umbilical arteries using Ultrasound equipment capable of high resolution grayscale, pulsed wave and color Doppler modes was used a 2-5MHz transabdominal probe (GE LOGIC p5, Japan and GE LOGIC p7, Japan). Doppler examination of foetal Umbilical artery was done with patients were placed in a semi recumbent position with a left lateral tilt, and selected area of amniotic cavity with several loops of cord seen by colour Doppler. Then using a pulsed wave Doppler on a free loop of cord, the characteristic sound and shape of the umbilical artery was identified. When the screen showed at least 3 consecutive wave forms of similar height, the image was taken and Doppler umbilical artery Resistant index (RI) and pulsatility index (PI) was estimated. A minimum of 3 separate reading were averaged before the final value were obtained. Umbilical artery Doppler studies were avoided during fetal breathing because of effect of fetal breathing movements on waveform variability.

The normal wave of umbilical artery is saw tooth appearance. Decreased diastole, absent diastole or reversed diastole were considered as abnormal waves. The measurement of RI, PI of umbilical artery was considered normal or abnormal according to percentiles for gestational age.

For Doppler examination of Middle ccerebral artery, transverse view of the fetal brain was obtained at the level of the biparietal diameter. The transducer was then moved towards the base of the skull at the level of the lesser wing of the sphenoid bone. Using color flow imaging, the middle cerebral artery was seen as a major lateral branch of the circle of Willis, running anterolaterally at

the borderline between the anterior and the middle cerebral fossa. The pulsed Doppler sample gate was then placed on the middle portion of this vessel to obtain flow velocity waveforms. When the screen showed at least 3 consecutive wave forms of similar height, the image was taken and Doppler Middle cerebral artery Resistant index (MCA-RI) and pulsatility index (PI) was estimated. A minimum of 3 separate reading were averaged before the final values were obtained care should be taken to apply minimal pressure to the maternal abdomen with the transducer, as fetal head compression is associated with alterations of intracranial arterial waveforms in normal pregnancies the diastolic component in the cerebral arteries is lower than in the umbilical arteries at any gestational age. Therefore the cerebral vascular resistance remains higher than the placental resistance. The measurement of RI and PI of Middle cerebral artery was considered normal or abnormal according to percentiles for gestational age.

Cerebroplacental ratio as MCA PI above UMA PI (MCA PI/UMA PI) and its value usually costant after 26 weeks so, cut off point of 1 was used, above which velocimetry was considered normal and below which was considered abnormal. Follow-up of the cases was done to know perinatal outcome.

Statistical analysis:

Data were analyzed with SPSS (statistical package for the Social Science; spss Inc, Chicago, IL, USA) release 15 for Microsoft Windows (2006). The normality of data was first tested with one-sample Kolmogorov-Smirnov test. Qualitative data were described using number and percent. Association between categorical variables was tested using Chi-square test. Continuous variables were presented as mean ± SD (standard deviation) for parametric data and Median for non-parametric data. The two groups were compared with Student *t*-test (parametric data) and Mann-Whitney test (non parametric data). Accuracy was represented using the terms sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and overall accuracy. Level of significance: For all above mentioned statistical tests done, the threshold of significance is fixed at 5% level (*p*-value). The results were considered: Non-significant when the probability of error is more than 5% (*p* >0.05). Significant when the probability of error is equal or less than 5% (*p*<0.05).Highly significant when the probability of error is less than 0.1% (*p* <0.001). The smaller the *p*-value obtained, the more significant are the result.

Results

The study included 100 pregnant women divided into two groups: Group A (High risk group) 50 patients with high risk pregnancy, group B (Control group) 50 patients with normal pregnancy. The mean maternal age in group A was 28.36 in comparison with group B the mean was 26.34. The mean of foetal gestational age was 35.3 in group A and 34.3 in group B but the mean of maternal gravidity was the same in both groups (Table 1).

In group A, the mean of resistive index (RI) of UMA was 0.70 and the mean of pulsatility index (PI) was 1.64, In group B the mean of RI of UMA was 0.55 which was statistically significant different from group A and the mean PI of UMA in group B was 0.96. The middle cerebral artery resistive index (RI) mean was 0.73 in group A and 0.77 in group B, The pulsatility index of MCA (PI) mean was 1.41 in group A and 1.57 in group B (Table 2).

In group A (High risk group), out of 18 cases with abnormal UMA Doppler indices 7 cases (14%) had perinatal foetal death, 2 cases (4%) had babies with respiratory distress syndrome (RDS), 6 cases (12%) had babies admitted to neonatal intensive care unit (NICU) and 3cases were lucky to have normal babies, because Doppler changes of umbilical artery were mild. Also out of 14 cases with abnormal MCA 4 cases (8%) had perinatal foetal death, 3 cases (6%) had babies with RDS, 4 cases (8%) had babies admitted to NICU and 3 (6%) cases had normal babies. In group B (Control group), only one case (2%) had perinatal foetal death, these case had abnormal both UMA, MCA and CPR Doppler indices. Another case had abnormal umbilical artery but the foetus was born without any complication (Table 3).

The sensitivity, specificity, PPV, NPV of resistive index (RI) of umbilical artery were 70%, 60%, 54.7%, 58.3%, 63% respectively and 70%, 46%, 56.5%, 60.5%, 58% for umbilical artery pulsatility index (PI) (Table 4).

The Middle cerebral artery resistive index showed sensitivity, specificity, PPV, NPV of 74%, 48%, 58.7%, 64.9% respectively and 70%, 60%, 63.6%, 66.7% and 65% respectively for Middle cerebral artery pulsatility index (Table 4).

Table (1): Demographic and clinical data of the studied groups.

Variables	Group B (n=50)		χ^2	p-value
Age/years:				
Mean ± SD	28.36±5.37	26.34±4.07	t=0.550	0.584
Min-Max	20-42	19-37		
Gravidity:				
Median (Min-Max)	2 (1-5)	2 (1-5)	Z=0.208	0.835
<3	32 64.0	31 62.0	χ^2=0.043	0.836
≥3	18 36.0	19 38.0		
Gestational age:				
Mean ± SD	35.30±4.33	34.31±3.79	t=1.21	0.277
Min-Max	27-42.5	26.5-39.5		

t : Student *t*-test.   Min: Minimum.
Z : Mann Whitney test.   Max: Maximum.
χ2 : Chi square test.   SD : Standard deviation

Table (2): Resistive index of umbilical artery, Pulsatility index of umbilical artery, Resistive index of middle cerebral, Pulsatility index of middle cerebral artery in the studied groups.

Variables	Group A (n=50)	Group B (n=50)	t-test	p-value
Resistive index of umbilical artery:				
Mean ± SD	0.70±0.28	0.55±0.11	3.66	<0.001**
Min-Max	0.38-1.40	0.33-1.0		
Pulsatility index of umbilical artery:				
Mean ± SD	1.64±1.87	0.96±0.29	2.53	0.013*
Min-Max	0.56-9.15	0.63-2.01		
Resistive index of middle cerebral artery:				
Mean ± SD	0.73±0.09	0.77±0.05	2.83	0.006*
Min-Max	0.52-1.0	0.67-0.88		
Pulsatility index of middle cerebral artery:				
Mean ± SD	1.41±0.44	1.57±0.30	2.10	0.038*
Min-Max	0.73-3.13	0.91-2.67		

SD : Standard deviation.   Min : Minimum.
t : **Student** *t*-test.   Max : Maximum.

Table (3): Correlation between abnormal Doppler indices and fetal outcome.

	Group A (n=50)				Group B (n=50)			
	Fetal death	RDS	NICU	Normal fetus	Fetal death	RDS	NICU	Normal fetus
Abnormal UM	7	2	6	3	1	0	0	1
Abnormal MCA	4	3	4	3	1	0	0	0
Abnormal CPR	4	1	4	1	1	0	0	0

UMA: Umbilical artery.   MCA: Middle cerebral artery.   CPR: Cerebroplacental ratio.
RDS : Respiratory distress syndrome.   NICU: Neonatal intensive care unit.

Table (4): Sensitivity and specificity of Resistive index and Pulsatility index of both umbilical artery and Middle cerebral in predicting foetal outcome.

	Sensitivity	Specificity	PPV	NPV	Accuracy
UMA RI	70%	60%	54.7%	58.3%	63%
UMA PI	70%	46%	56.5%	60.5%	58%
MCA RI	74%	48%	58.7%	64.9%	61%
MCA PI	70%	60%	63.6%	66.7%	65%

UMA RI : Umbilical artery resistive index.   MCA in : Middle cerebral artery pulsatility index.
UMA PI : Umbilical artery pulsatility index.   PPV   : Positive predictive value.
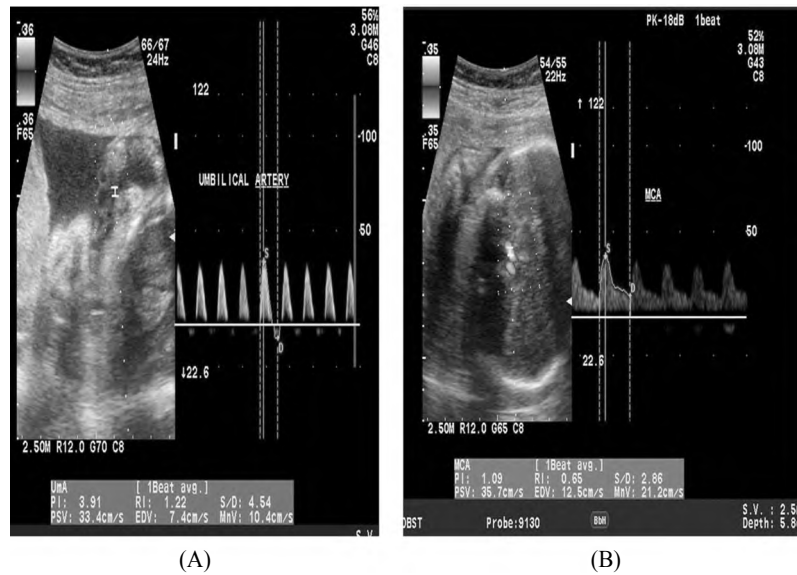MCA RI : Middle cerebral artery resistive index.   NPV   : Negative predictive value.

Fig. (1): Case (1): Pregnant female 30 year old, gravida 3 with a history of pre-eclampsia examined for antenatal care, GA by LMP=34 ws,GA by US=35w 3d. (A): Abnormal umbilical artery indices (RI=1 .22,PI=3 .91) with reversed end diastolic flow (B): Abnormal MCA Doppler indices (RI=0.65, PI=1.09) (brain sparing effect) (CPR)=0.278.
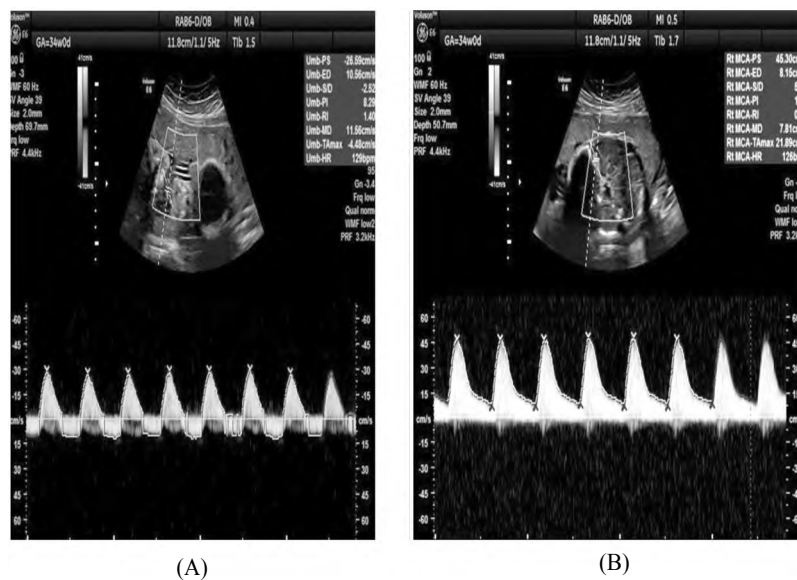

Fig. (2): Case (2): Pregnant women 29 year old, presenting with pre-eclampsia and IUGR,GA by LMP=38ws, GA by us=34 ws, EFW=1300gm (A): Abnormal UMA Doppler indices (RI=1.40,PI=8.29) with reversed end diastolic flow (B): Normal MCA Doppler indices. (RI=0.82, PI=1.7) CPR=0.20.

Discussion

A total of 100 pregnant women were included in this study, 50 of them had a high risk factor were selected e.g gestational diabetes, preeclampsia, placental abnormalities, maternal or foetal anaemia, congenital foetal anomalies and twin pregnancy, the remaining 50 women had no obstetric disorder or risk factors were selected as control. All pregnant women underwent uniform antenatal assessment protocol that includes umbilical artery (UA) and middle cerebral artery (MCA) Doppler ultrasound studies and cerebroplacental ratio (CPR) was calculated as MCA PI/UM PI.

In our study, the mean of gestational age in group A (high risk group) and group B (control group) were (28.36-26.34), these was similar to study conducted by Garcia, et al., [9], Wald, et al., [10] and Rai L., et al., [11] . The mean of foetal gestational age was 35.3 in group A and 34.3 in

group B but the mean of maternal gravidity was the same in both groups.

Ghosh et al., 2017 showed in their study of high risk pregnancy that Oligohydramnios, Pre-eclamsia and anemia are the most common pregnancy complications respectively [12]. In our study, the most common risk factor was pre-eclampsia (26.0%) followed by maternal anaemia (20.0%) and gestational diabetes (18.0%). The study also included cases with oligohydraminous (12.0%), polyhydraminous (6.0%), postdate pregnancy (10.0%), placenta previa (6.0%), foetal anomalies (6.0%), IUGR (6.0%), foetal anaemia (2.0%), twin pregnancy (4.0%) and Cardiac mother (2.0%). Bansal, et al., [13] stated in their study that. The most common high risk group in the study group was Pegnancy induced hypertension (PIH) (38%), either alone (22%) or in combination with other risk factor like IUGR, The second most common high risk group was IUGR either alone (18%) or in combination with PIH, bad obstetric history (BOH), Anaemia and Rh negative pregnancy (26%). The other high risk group include BOH (10%) alone and along with other risk factors like IUGR and PIH (4%), Rh negative pregnancy(8%) alone and along with IUGR (4%), ante-partem haemorrhge (APH) (10%) and Diabetes (6%) [13].

We found that Doppler indices of both umbilical and middle cerebral arteries in the control group decrease with increasing gestational age this match with Khalid, et al., [14] that stated at normal pregnancy all Doppler indices showed a progressive decline with advancing gestational age [14].

The umbilical artery has been the first and the most studied artery since the introduction of Doppler ultrasound in obstetrics. The absence of diastolic flow or reversed diastolic blood is often associated with adverse outcome of pregnancy, e.g. IUGR and fetal hypoxia [15].

In our study, the mean of PI and RI of umbilical artery were significantly higher in high risk group (1.64,0.70) than control group (0.96,0.55), these was nearly similar to the finding of the study conducted by Bansal et al., who stated that the PI, RI and S/D of the umbilical artery were significantly higher in the study group (1.70, 0.74, 3.84) than the control group (0.84, 0.56, 2.15), indicating increased peripheral resistance and consequently decreased diastolic flow leading to fetal compromise [13].

We found that MCA is high resistence vessel with decrease of resistence with gestational age and incases of cerebral redistribution in foetal hypoxia. The recent studies suggested that, in cases with cerebral blood flow redistribution, low gestational weight fetuses were at risk of later neurodevelopmental deficits. Thus, the middle cerebral artery Doppler is an essential diagnostic tool [15].

The mean of PI and RI of MCA in our study was lower in group A (high risk group) (1.41,0.73) than in group B (control group) (1.75,0.77) indicating increase in the diastolic flow and cerebral vasodilatation, Bansal, et al., found also in their study that the PI, RI and S/D ratio of MCA in high risk pregnancy group 1.08, 0.66, 3.03 were lower than the control group [13].

Recently, the cerebral/umbilical ratio (C/U ratio) has been recognized as the most sensitive and specific indicator of likelihood of IUGR and adverse perinatal outcome in high-risk pregnancies [16].

We found that the value of calculated CPR was nearly constant during the third trimester Similar finding was found by Bano et al., 2010, who calculated in their study that included 90 patients the cerebro-umbilical ratio (C/U) (the ratio of MCA PI to umbilical artery PI) and found that it remained constant in the last 10 weeks of pregnancy and therefore used a single cut off value of 1.08 for all cases of 31-40 weeks of gestation. Above this value, Doppler velocimetry were considered normal and below it abnormal [17].

In our study, the cases with abnormal Doppler indicies was associated with increase risk of perinatal morbidity and mortality. These was similar to Urmila, et al., who stated in their study of 50 patient with high risk pregnancy that. The umbilical and MCA artery indices were abnormal in the group whose babies were admitted in the nursery as compared to those whose babies were not admitted. This implied poor perinatal outcome in the presence of abnormal indices and hence in the presence of fetal anoxia [18].

In our study, in group A (high risk group) out of 18 cases with abnormal UM artery Doppler, 7 cases was associated by perinatal foetal death and 8 cases was associated with perinatal mortality and out of 15 cases with abnormal MCA Doppler, 4 cases was associated with perinatal foetal death and 7 cases with perinatal mortality.

Amin et al., also found in their study that included 100 pregnant women with risk factor, out of 46 pregnancies with abnormal Doppler results, 19 cases had perinatal mortality, 11 cases had morbidity associated with pregnancy outcome, as

compared to patients with normal Doppler wave-forms, 46 had normal perinatal outcome, 2 had perinatal mortality of unknown cause and 6 had perinatal morbidity which indicate good relation between abnormal Doppler indices and worse perinatal outcome [19].

In our study, the sensitivity, specificity, PPV, NPV of resistive index (RI) of umbilical artery were 70%, 60%, 54.7%, 58.3%, 63% respectively and 70%, 46%, 56.5%, 60.5%, 58% for umbilical artery pulsatility index (pI). The Middle cerebral artery resistive index showed sensitivity, specificity, PPV, NPV of 74%, 48%, 58.7%, 64.9% respectively and 70%, 60%, 63.6%, 66.7% and 65% respectively for Middle cerebral artery pulsatility index. Gaikwad PR., et al., 2017, showed in their study that included pregnancy induced hypertension (PIH) as high risk group, UMA RI showed sensitivity of 37.8%, specificity 79.7% and accuracy 65.09%, and UMA PI with sensitivity of 29.7%, specificity 92.7% and accuracy 70.7% [20]. They also found in their study, that sensitivity of MCA RI was 10.8, specificity 94.2% and accuracy 65.09%, and MCA PI with sensitivity of 21.7%, specificity 85.5% and accuracy 63.21% [20]. In another study conducted by Paliwal S., et al., [21] of Comparative role of non-stress test and colour doppler in high risk pregnancy predicted by placental histopathology and foetal outcome, they found that colour Doppler give sensitivity of 47.2% and specificity of 96.87% [21].

Conclusion:

This study concluded that, Doppler investigation of the feto-maternal circulation plays an important role in monitoring high risk pregnancies complicated by placental vascular insufficiency and fetal growth restriction (FGR) and predicting foetal outcome.

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تقييـم دور الموجات فوق الصوتيـة والدوبلر الملون للشريان المخى الأوسط والشريان السرى للجنيـن فى الحمل عالى الخطورة

لقد وفر إدخال تكنولوجيا الدوبلر أول فرصة لرؤية الدورة الدموية خلال فترة الحمل بطريقة آمنة يمكنها التنبؤ بشكل موثوق فيه بالنتائج السلبية لما قبل الولادة فى الحمل مع أرتفاع أنتشار الضاعفات ومقارنة مع غيرها من أساليب مراقبة الجنين ثبت أنها أكثر حساسية فى الكشف عن المشاكل الجنينية فى وقت مبكر. حيث أن الهدف الرئيسى من مراقبة ما قبل الولادة هو الأكتشاف المبكر فى الوقت المناسب لمشاكل الجنين حتى يمكن التدخل المناسب ومنع المزيد من المضاعفات الخطيرة فالدوبلر الملون يمكنه الكشف عن التغيرات الخاصة بالدورة الدموية بين الرحم والمشيمة وبين المشيمة الجنين.

وكان هدف هذه الدراسة هو تقييم دور الدوبر الملون والموجات فوق الصوتية على كل من للشريان المخى الأوسط للجنين الشريان السرى فى الحمل عالى الخاطر للتنبؤ بنتائج الولادة.

حيث شملت الدراسة ١٠٠ إمرأة حامل مقسمة إلى مجموعتين مجموعة (أ) (مجموعة الحمل عالى الخطورة) وشملت ٥٠ مريضة تعانى من الحمل عالى الخطورة مجموعة (ب) (مجموعة المقارنة) وشملت ٥٠ مريضة ذات حمل طبيعى.

ونستنتج من دراستنا أن فحص الدورة الدموية للأم والجنين بإستخدام الدوبلر يلعب دوراً هاماً فى رصد حالات الحمل عالية المخاطر المرتبطة بحالات قصور المشيمة أو تأخر نمو الأجنة. وهناك علاقة إيجابية بين وجود مؤشرات طبيعية للدوبلر وبين النتيجة النهائية لمشاكل حديثى الولادة وبالتالى يدل ذلك على الدور الهام الذى يلعبه دور الدوبلر لحالة الجنين وبالتالى تحديد الموعد الأنسب للولادة.