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Review Article

THE VALUE OF DOPPLER ULTRASOUND IN THE PREDICTION OF MATERNAL AND FETAL OUTCOMES IN PATIENTS WITH PREECLAMPSIA

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ABSTRACT

Objective-To determine the value of Doppler ultrasound in the prediction of maternal and fetal outcomes in patients with preeclampsia.

Keywords: Doppler Ultrasound,Umbillical Artery, Uterine Artery, Middle Cerebral Artery,Perinatal Outcomes

INTRODUCTION

Preeclampsia (PE) is one of the hypertensive disorder of pregnancy which is characterized by elevated blood pressure and with/without proteinuria(according to new guidelines for diagnosis of PE by ACOG).Despite recent advances in antenatal care, pre-eclampsia has remained a major cause of maternal and perinatal morbidity and mortality.Doppler Ultrasound (US) evaluation has been considered a useful method for prediction of PE as it can detect the abnormal blood flow pattern which can be warning sign for development of PE.The aim of this study was to evaluate the uterine, umbilical, and the middle cerebral arteries using Doppler US parameters [resistance index (RI), pulsatile index (PI), notch (N), systolic peak (SP) and their combinations] in 24 to 37 weeks of gestation. The etiology of PE is still unknown, although an excessive maternal systemic inflammatory response and an imbalance between circulating angiogenic and anti-angiogenic factors have been described. The pathophysiology of PE is based on the incapability of the trophoblast to invade properly the myometrium causing a limited remodeling of spiral arteries. The impaired placental perfusion caused by vascular abnormalities precedes clinical manifestation of PE and it can be detected by Doppler ultrasound .However, ductus venosus (DV) is also look in the PE patients but it is used in severe form to decide whether or not quick actions have to be taken immediately or can be waited for delivery.In this review article indivisual significance of uterine artery,umbilical artery,middle cerebral artery and cerebroplacental ratio (CPR) in detecting PE is evaluated and compared with each others.

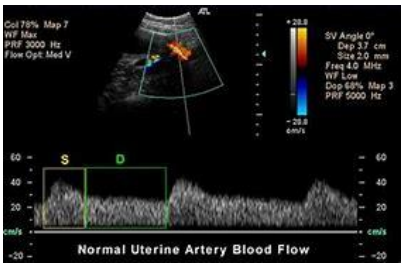
Abnormal values of Uterine artery, Umbilical artery, middle cerebral artery Doppler:

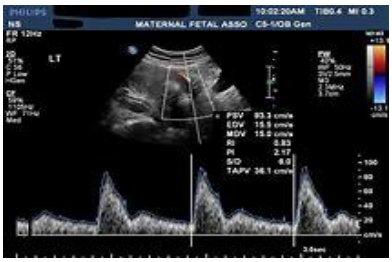
The abnormality in the wave morphology was considered as the presence of a diastolic Notch after the 24 GW in the uterine artery .In early trimester even presence of notch is found to be normal.The RI and PI values above the 95th percentile standardized for the gestational age were considered abnormal for the uterine and umbilical arteries, and below the 10th percentile for the middle cerebral artery.Alterations in any of the uterine artery parameters were interpreted as an abnormal result of this artery but the presence of notch is found to be meaningful [1].In the umbilical vessel, alterations in the individual or combined RI and PI values were reported as an abnormal artery result. Decreases of individual RI or PI values,as well as their combination in the middle cerebral artery were considered as an abnormal artery result. For umbilical and middle cerebral vessels only their combination with another abnormal artery was considered to report and abnormal general Doppler [1].

Significance of Uterine Artery Doppler in detecting Preeclampsia:

Uterine artery is used as an important artery to predict the prognosis and outcome of pregnancy. Early studies used mainly continuous-wave Doppler, more recently, color flow mapping has been used to identify vessels, either trans abdominally (at the apparent crossover with the external iliac artery) or trans vaginally (lateral to the uterine cervix at the level of the internal cervical os. Before 1990,there used to be two stage screening one stage done at 18-20 WOG and second stage screening done at 23-24WOG.Now the study is usually performed at 23-24 WOG as only one stage screening.An abnormal test result is represented by either an abnormal flow velocity ratio(systolic to diastolic velocity(S/D) ratio,pulsatile index(PI)or resistance

index(RI) and the presence of early diastolic notch.The most frequent studies emphasizes on the measurements of impedance and velocity indices and the presence of uterine artery notches.



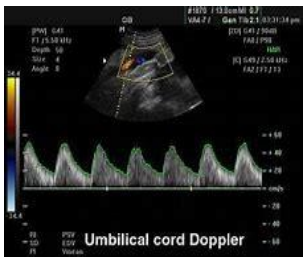


Uterine artery role in maternal and perinatal outcomes in preeclampsia:

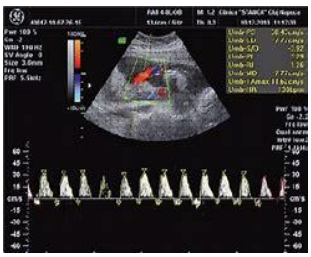
The impedance to flow in the uterine arteries decreases with gestation in normal pregnancies, reflecting the trophoblastic invasion of the spiral arteries and their conversion into low-resistance vessels. Studies in pregnancies with established pre-eclampsia or fetal growth restriction have shown that impedance to flow in the uterine arteries is increased。However the uterine artery Doppler study is found to be better at predicting severe form of disease than mild form[2]。Few study have shown that abnormal uterine artery Doppler in first trimester later predisposing to pre-eclampsia and FGR .In women with increased impedance to flow, has shown, for example, in the study by Steel et al, the sensitivity of increased impedance in the uterine arteries for pre-eclampsia was 63% and for gestational hypertension it was 39%[3]. In the study Papageorghiou et al stated the sensitivity for pre-eclampsia with FGR was 69%, whereas for pre-eclampsia without FGR it was 24%.Papageorghiou et al reported that increased PI identified 41% of women who later developed pre-eclampsia; the sensitivities for preeclampsia requiring delivery before 36, 34 and 32 weeks were 70, 81 and 90%.pre-eclampsia can be predicted by abnormal Doppler in the first trimester but the sensitivity is lower than in second trimester Doppler study [4].The abnormal uterine artery Doppler results was higher in more severe degrees of FGR. Thus, in studies providing data on birth weight below the 10th, 5th and 3rd centiles, an increase in sensitivity was seen with decreasing birth weight centile [5]. Papageorghiou et al reported that mean PI above the 95th centile of the normal range at 23 weeks identified 16% of pregnancies delivering an infant with birth weight below the 10th centile and that this increased to 53, 64 and 74% for birth weight below the 10th centile delivering before 36, 34 and 32 weeks, respectively [6]. When comparing the parameters i,e PI and RI with the diastolic notch in high-risk population, the best performance is given by mean PI and mean RI [7] . Screening by uterine artery Doppler imaging is particularly effective in identifying severe early-onset pre-eclampsia with SGA rather than late-onset disease with less effect on fetal growth [8]. Thus overall the uterine artery Doppler can detect the pregnant women who are at increased risk of developing PE and also help in early recognition of fetus who are at increased risk of adverse perinatal outcomes. An abnormal Doppler flow pattern and resistance to flow in the UA are strong predictors of the of PE, it is recommended that patients at high risk for these adverse pregnancy outcomes be offered ultrasound screening.

Umbilical artery role in predicting maternal and perinatal outcomes in preeclampia:

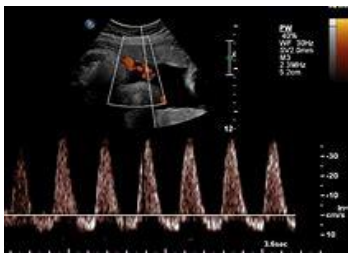
The use of Doppler ultrasound to investigate the pattern of waveforms in the umbilical artery during pregnancy was first reported in 1977 from Dublin. Umbilical artery measures were taken in a free umbilical cord loop. Doppler indices from the umbilical artery start to increase when approximately 60% to 70% of the placental vascular tree is not functioning (Thompson 1990).Under normal physiologic conditions of pregnancy, the placenta presents an area of low vascular impedance thus allowing continuous forward blood flow throughout the cardiac cycle .Because blood flow in diastole is mostly passive, as placental impedance increases the umbilical arterial diastolic flow decreases. Therefore, elevated placental impedance is associated with either low, absent, or even reversed end diastolic blood flow. An abnormal result of an umbilical artery Doppler study reflects the presence of placental vascular pathologic mechanisms and identifies pregnancies at increased risk for perinatal mortality.



Normal End Diastolic Blood Flow



Absent End Diastolic Blood Flow



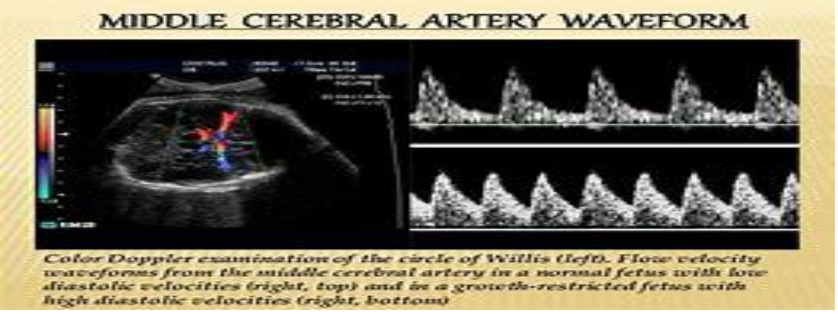
Reversed Diastolic Blood Flow

Most of the study had focused on the prediction of maternal outcome like hypertensive disorders of pregnancy,vaginal delivery or cesarean section and fetal outcomes like fetal distress, meconium, fetal asphyxia, admission to the neonatal intensive care unit, and perinatal mortality[4]More recently Laurini et al[5] confirmed the existence of a significant relationship between ischemic pathologic features of the placenta and abnormal umbilical artery Doppler studies in growth-retarded fetus . Elective Cesarean section in the Doppler velocimetry and control groups were 12% in each case, and emergency Cesarean section rates were 12.3% for the Doppler velocimetry group and 15.0% for the control group.[4]The rates of low Apgar score (< 7) at 5 min were 4.2% for the Doppler velocimetry group and 5.6% for the control group[4] .Birthweight below the 10th percentile for gestational age are constitutionally small and therefore should not be expected to have abnormal umbilical Doppler study results. Several studies have shown that severe forms of Doppler abnormality such as absent or reversed end-diastolic flow are significantly associated with suboptimal fetal outcome. In Arauz et al study abnormal umbilical artery Doppler velocimetry was present in 52% of preeclamptic patients and they suffered more from adverse neonatal outcomes than those with normal Doppler indices [9]. The results of Seyam et al's study revealed that fetuses with abnormal UA velocity waveforms are at a significantly increased risk for oligohydramnios, early delivery, decreased birth weight, and neonatal intensive care unit admissions [10].Although the abnormal parameter not necessarily indicate the bad outcomes but it can act as warning signs for further management in the future.The studies have shown that the abnormal result can be compared by measuring blood flow in uterine artery and middle cerebral artery in early and late pregnancy respectively.

The end diastolic blood flow is the indication for taking early decision to terminate the pregnancy if it is >34WOG or to keep the pregnancy till the maturation of fetal lung if it is <32WOG.Whereas the reverse diastolic blood flow indicates the emergency termination of pregnancy. Thus each parameters PI, RI, S/D as well as the end diastolic blood flow all play major role for adverse outcomes.

Middle cerebral artery role in predicting maternal and perinatal outcomes in preeclampsia:

Fetal middle cerebral arterial (MCA) Doppler assessment is an important part of assessing fetal distress, fetal anemia or fetal hypoxia. In most of the situation it is a very useful when combine to umbilical artery Doppler assessment. The MCA vessels are often found with color or power Doppler ultrasound overlying the anterior wing of the sphenoid bone near the base of the skull. In the normal situation the fetal MCA has a high resistance flow which means there is minimal antegrade flow in fetal diastole.in pathological states the mechanism of blood flow reverse so that there is low resistance flow with increase diastolic blood flow. In a situation of chronic fetal hypoxemia, the fetus redistributes its cardiac output to maximize the oxygen supply to brain by vasodilation of the cerebral arteries mainly as a result of the ''brain sparing effect'' Parameters used include:fetal MCA (PI),fetal MCA peak systolic velocity (PSV): the highest velocity should be recorded,fetal MCA (S/D) ratio: a normal fetal MCA S/D ratio should always be higher than the umbilical arterial S/D ratio.



Color Doppler examination of the circle of Willis (left). Flow velocity waveforms from the middle cerebral artery in a normal fetus with low diastolic velocities (right, top) and in a growth-restricted fetus with high diastolic velocities (right, bottom)

Most of the time the umbilical artery and middle cerebral artery is look hand in hand to confirm the abnormality.Many studies has shown the combined effectiveness of UA and MCA dopplar study rather than indivisual effectiveness. For fetuses recruited before 32 weeks, MCA Doppler studies had a sensitivity of 95.5% and a negative predictive value of 97.7% for major adverse perinatal outcomes (including death). Amongst fetuses 36 weeks gestation, four out of nine with adverse outcomes had MCA Doppler values, 5th percentile [11]. Riskin-Mashiah S *et al.* [12] reported that women destined to develop pre-eclampsia had lower middle cerebral artery (MCA) resistance index (RI) and pulsatile index (PI) weeks before the development of pre-eclampsia. Severi *et al*. [13] concluded that SGA fetuses with abnormal fetal MCA waveforms have an increased risk of developing distress and being delivered by emergency cesarean section. This study suggests that MCA indices are predictive of the development of adverse perinatal outcome in pre-eclampsia patients. Therefore, Doppler investigation of the fetal cerebral circulation may play a key role in monitoring the fetal outcome, and helps to determine the optimal time for delivery.

The significance of CPR in predicting perinatal and maternal outcomes in preeclampsia:

The CPR is calculated as the ratio of MCA PI to UA PI. The cerebroplacental ratio(CPR) can predict the alternation in blood flow pattern in brain which manifest as increased diastolic flow in middle cerebral artery whereas decreased diastolic flow of umbilical artery as result of ungoing fetal hypoxia and increased placental resistance. The abnormal UA and MCA doppler waveforms are considered abnormal when above 95^{th} or below 5^{th} percentiles respectively. The normal CPR value is taken as 1.08. When analysing data from different studies, the results shows CPR to be a good predictor of emergency operative delivery due to fetal distress [6]. The value of CPR as a predictor of foetal UA and MCA Doppler flows should be measured in all pregnancies complicated by growth restriction and CPR calculated. It is useful in predicting those fetuses that might require careful surveillance and should be taken into consideration when looking after these high risk pregnancies in the antenatal period and during labour.CPR at term in appropriately grown foetuses has been shown by Prior et al. to be a predictor for intrapartum foetal compromise and the need for emergency caesarean delivery [14]. Similarly, Khalil et al used multivariate logistic regression analysis on the 8382 patients scanned after 37 weeks and found that CPR was associated with the risk of emergency operative delivery in both SGA as well as AGA patient, this finding was independent of birthweight [15]. CPR also showed the highest sensitivity in prediction of both the intrapartum suspected foetal distress (74.1%) and the adverse neonatal outcome [15]. They found that the CPR <10th centile has a sensitivity and specificity of 55.6% and 87.9% respectively, for Caesarean section due to foetal compromise [15]. The measurement of CPR is an important non-invasive procedure to evaluate adverse fetal outcome and enables for the identification of high-risk patients even in some of the low risk patients, non-selected patient population, which could possibly lead to a reduction in perinatal morbidity.

DISCUSSION

We reviewed different studies on the prognostic accuracy of UA, MCA and CPR doppler findings. Each components are measured indivisually and compared with each others. In the fetal condition,the presence of notch in uterine artery in second trimester is matter of concern , the umbilical artery has been related typically to pregnancy outcome, while the middle cerebral artery has been considered as a fetal circulation marker and a useful non-invasive tool in risk assessment for fetal hypoxia. In this study, as individual measurements, abnormal PI and RI from uterine artery,umbilical artery and altered PI from umbilical and middle cerebral arteries, were associated to PE.Also the importance of CPR is evaluated in various study in determining the outcomes.However, considering all the parameters reviewed in these arteries, the general results for each vessel did not show a difference between groups, suggesting that these individual parameters should be evaluated .There is no any specific artery found to play superior role in determining the maternal and fetal outcomes but rather all the arteries are found to play important role indivisually.

CONCLUSION

Although it is obvious that a diseased placenta may result in adverse fetal outcome,the physiologic mechanisms of fetal compensation and the rate of subsequent fetal deterioration is different for different fetus so the outcome are unpredictable, complex and poorly understood that several issues must be considered to understand the role of doppler study in clinical practice.The abnormal study in each artery is not related with each other.The findings should be compared and evaluated to make effective decision. Doppler study helps us to take time to plan and manage the patients in future deliveries.

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