Comparison of foetomaternal circulation in normal pregnancies and pregnancy induced hypertension using color doppler studies

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Abstract

The aim of the present study was to assess fetomaternal blood flows in normal and abnormal pregnancies using color doppler indices. Subjects were divided into two groups as: Group A of 25 subjects of normal pregnancy as controls and group B of 25 subjects of pregnancy induced hypertension. All the subjects were lying in the age-group of 25-35 years and having 28 to 34 weeks of gestation; the patients were evaluated by detailed history and were subjected to complete general examination. Blood pressure was taken on two occasions at least 6 hours apart. Systemic examination and obstetrical examination was done in all subjects. All cases were subjected to pathological tests- Haemogram, Test for proteins in urine. Ultrasound assessment of fetal growth was done by measuring BPD (Biparietal diameter), HC (Head circumference), FL (Femur length) and AC (Abdominal circumference). Average gestational age and effective fetal weight was then calculated by ultrasound machine. Color Doppler was used to assess the various doppler indices indices: Pulsatility index (PI), Resistive index (RI) and Systolic diastolic ratio (S/D ratio) in bilateral uterine, umbilical and middle cerebral arteries and compared to the standard normograms. Percentage of subjects having abnormal doppler indices were calculated. Assessment of percentage of SGA (small for gestational age) fetuses was done in all the three groups. Decline in mean values of all doppler indices was found with advancing gestational age in normal pregnancy suggesting decreased vascular resistance and increased blood flow in fetomaternal circulation. In pregnancy induced hypertensives, the mean values of doppler indices showed a decline as in normal pregnancy but showed an increase (more than 2 S.D. of the mean) for that gestational age in comparison to the control group suggesting increased impedance to blood flow in uteroplacental and fetomaternal circulation. Umbilical artery doppler indices were found to be the most sensitive indicator of uteroplacental and fetoplacental insufficiency in pregnancy induced hypertensives (P=0.001). Thus we concluded that color doppler can detect changes in fetomaternal circulation which correlate strongly with the fetal growth and therefore associated with pregnancy outcome.

Introduction

Pregnancy is an important physiological phenomenon. Complications in pregnancy may occur, which if detected beforehand can avoid unnecessary
morbidity and mortality. The main goal of prenatal testing is to identify fetuses at increased risk for perinatal morbidity and mortality. The traditional methods of fetal surveillance like non-stress test, fetal heart monitoring and fetal biophysical profile are no more ideal tests because of their inability to detect early stages of fetal distress, significant number of false positive tests and low predictive value. Modern science gave us ultrasound which provides a boon for physiological assessment of blood flow in normal and high risk pregnancies. Further advancement led to color doppler coming to the fore which made it possible to predict in advance the outcome of pregnancy. Color Doppler used changes in velocity of blood flowing in different vessels during systole and diastole and waveform representation and their analysis. Vascular resistance in these vessels can be inferred and obstetrician can be told the possible fetal outcome. Ultrasound should be carried out at 28-34 weeks to assess fetal growth and placental insufficiency.

Color doppler studies can be used for assessment of uteroplacental and fetal blood flow in evaluation of growth retardation as can be found in high risk pregnancies like pregnancy induced hypertension (PIH). PIH is defined as hypertension that develops as a direct result of gravid state with an absolute rise of blood pressure of at least 140/90 mm Hg, if previous BP is not known/rise in systolic blood pressure of at least 30 mm Hg or a rise in diastolic blood pressure of at least 15 mm Hg over the previously known blood pressure/mean arterial pressure is 105 mm Hg or more (2). It is the most common complication during pregnancy and is the leading cause of maternal and fetal morbidity and mortality. It has many complications, the most common complication being the intra-uterine growth retardation (IUGR). Fetal surveillance in third trimester is necessary in order to detect placental insufficiency in normal pregnancies and pregnancy induced hypertension. Thus color Doppler waveform analysis of uteroplacental and fetal circulation was planned to evaluate fetal outcome in normal pregnancy and PIH. Though many studies have been done in this field abroad much work has not been done in our country. This study will endeavour to fill the gap.

Materials and Methods

The present study was conducted in Department of Physiology, SMC and associated C.S.S Hospital and Om Imaging Diagnostic centre, Meerut. The study comprised of two groups - group A (control group) and Group B (study group) with 25 subjects in each, lying in the age-group of 25-35 years with 28 weeks to 34 weeks of gestation. Following approval from our Institutional Research and Ethical Clearance Committee, written informed consent was obtained from all subjects recruited for this study. Form F was also got signed by all subjects for the prenatal diagnostic test formalities.

Inclusion criteria

Group A: Pregnant healthy females with normal BP (<140/90 mm Hg).

Group B: Pregnant females with diagnosed pregnancy induced hypertension i.e. pregnant females with an absolute rise in blood pressure value of at least 140/90 mm Hg or more in 28-34 weeks of gestation (PIH is defined as hypertension that develops as a direct result of gravid state with an absolute rise of blood pressure of at least 140/90 mm Hg, if previous BP is not known/ rise in systolic blood pressure of at least 30 mm Hg or a rise in diastolic blood pressure of at least 15 mm Hg over the previously known blood pressure/mean arterial pressure is 105 mm Hg or more (2)).

Exclusion criteria

Pregnant females having any other chronic medical illness as severe anemia (Hb <6 gm%), diabetes mellitus with or without treatment or subjects suffering from any other systemic or endocrine disorder. Patients with pre eclampsia and eclampsia were also excluded.

The patients were evaluated by detailed history and complete general examination including pulse, B.P, respiratory rate, pallor, odema, jaundice. Blood pressure was taken on the right arm, with the patient lying on her side at 30 degrees to the horizontal. The occluded brachial artery was kept at the level of
the heart. Blood pressure was measured by auscultatory method on two occasions at least 6 hours apart. Diastolic blood pressure was noted at the point of disappearance of Korotkoff –V sounds. Pitting oedema over the ankles after 12 hours bed rest was considered to be an earliest evidence of pre-eclampsia (1). Systemic examination including assessment of CVS, CNS and Respiratory System was done. Obstetrical examination including per abdomen examination was done in all subjects.

All cases were subjected to following pathological tests:

- Haemogram (by automated analyzer).
- Test for proteinuria: Done by multiple reagent strip (dipstick) method.
- Ultrasound assessment of fetal growth was done by using ultrasound machine with 3.5 MHz curvilinear probe. Biparietal diameter and head circumference were measured at a transverse plane passing the skull at the level of thalamus and cavum septum pellucida. Femur length (FL) was taken by measuring the ossified diaphyses of femur. Abdominal circumference (AC) was done at level of greatest transverse diameter of liver where the right and left portal veins meet. Then average gestational age and effective fetal weight were calculated through in ultrasound machine (2).

Color doppler indices:

1. Systolic/diastolic ratio (S/D ratio)
2. Pulsatility Index (PI) = S-D/Mean Velocity.
3. Resistivity Index (RI) = S-D/S

Where S = Peak Systolic Velocity, D = End Diastolic Velocity

In all velocity waveforms the inbuilt computer calculated the above ratios directly. These measurements were taken in a recumbent position during periods of fetal inactivity and apnea. The probe was positioned on the abdomen until best quality Doppler signal is obtained and this would be stored and played back later. Free floating loops of umbilical cord were examined to evaluate umbilical artery. Umbilical arteries values at the mid cord or placental insertion were taken as they were clinically reliable. Uterine arteries doppler studies were done at the level of crossing of internal iliac vessels. MCA Doppler studies were done at the level of Circle of Willis in Sylvian fissure. After recording the various waveforms the three indices were recorded on all three vessels (uterine, umbilical and middle cerebral arteries) and compared to the standard normograms. Doppler indices were considered abnormal when S/D ratio, PI and RI of each artery more than 2SD for the gestational age according to the reference values (2). Any vital variation would be brought to the notice of treating doctor for suitable and timely action.

Statistical analysis

All values were expressed as Mean ± SD. Differences between the study group and controls were examined using the unpaired Student's t test. A two tailed test (P<0.05) was considered statistically significant. The data were analyzed using the statistical package of Analytical Software SPSS (version 11.5).

Results

Umbilical artery doppler indices

Significant increase in all the three doppler indices of umbilical artery was found in study group as compared to control group. Out of which PI was found to be most significantly increased in study group (p=0.001). RI and S/D were also found to be significantly increased in study group (p=0.005, p=0.035) as shown in Table I.

Middle cerebral artery doppler indices

Significant decrease in all the three doppler indices of middle cerebral artery was found in study groups (p=0.05) as shown in Table I.

Uterine artery doppler indices

Statistical significant increase was found in RI in
study groups (p=0.05) as shown in Table I. PI and S/D in right uterine artery were showing an increasing trend, although not statistically significant (Table I).

Assessment of fetal growth patterns

In control group, effective fetal weight in all subjects was found to be in between 10th-90th percentile i.e. neither small for gestational age nor large for gestational age fetus was found. In Group B (pregnancy induced hypertensives, n=25), effective fetal weight in 5 subjects was found to be below 10th percentile (SGA in 20%) (Table II). Neither any abnormal doppler indices nor any intrauterine growth retardation was seen in controls. Out of 25 subjects of study group, 15 subjects (60%) showed abnormal umbilical artery indices, 10 subjects (40%) showed abnormal uterine artery indices and 6 (24%) showed abnormal middle cerebral artery indices in study group only 5 subjects were having intrauterine growth retardation. All the 5 (33%) showed abnormal umbilical artery indices whereas 4 (26%) of them showed abnormal uterine artery indices and only 2 (16%) of them were associated with abnormal middle cerebral artery indices (Table III).

Discussion

Decline in mean values of pulsatility index (PI) and resistivity index (RI) were found with advancing gestational age suggesting decreased vascular resistance and increased blood flow in uteroplacental and fetoplacental circulation. Similar results had been found in previous studies (14). It is supported by the fact that fetal growth during pregnancy depends on a steady supply of nutrients and oxygen from mother; a normal uteroplacental and fetoplacental circulation is necessary for this to occur. During pregnancy, the extravillous trophoblast migrates from the anchoring villi into the uterine decicua. These cells invade and surround the spiral arteries and convert these vessels from innervated and muscularized narrow vessels of high resistance to denervated, passively dilated vessels of low resistance. In addition to their invasive properties, the extravillous trophoblast cells promote maternal blood flow to the implantation site by the production of vasodilatory peptides locally in the deciduas and myometrium. Uterine blood flow in the nonpregnant woman is 50ml/min and increases to over 700 ml/min in the third trimester of pregnancy. The diastolic phase of the uterine artery doppler waveform is, thus, transformed during normal pregnancy from one of low peak flow velocity to one of high peak flow velocity by second trimester (2). Umbilical blood flow increases with the gestational age and pressure gradient driving the blood flow from the descending aorta through the placenta and back to inferior vena cava. As pregnancy advances there is increasing end-diastolic flow velocity with lesser changes in peak systolic velocity (3).

There is a progressive fall in the values of Doppler indices of the Umbilical artery with increasing
gestation, this decrease in the values with advancing gestation occurs due to decreased placental vascular resistance. This decrease does not occur in hypertensive pregnancies, which therefore have high values of Doppler indices (4). According to our study in pregnancy induced hypertensives, all three doppler indices showed a decline as in normal pregnancy but the individual values were usually above 2 S.D. of the mean for that gestational age in controls. Systolic/Diastolic ratio of more than 3 in umbilical artery was considered as an abnormal value after 30 weeks of gestation & concluded that placental vascular resistance between 31-34 weeks of gestation was higher in lower weight group as compared to normal weight for gestational age as also revealed by our study (1). In our study it is found that in normal pregnancy the volume of blood flow in umbilical arteries increases with advancing gestation. Thus high vascular impedance detected in the first trimester gradually decreases. This happens due to increasing number of functioning vascular channels. End diastolic velocity is often absent in the first trimester and end diastolic component increases with advancing gestation (5).

Increased values of Pulsatility index, resistive index and systolic/diastolic ratio of uterine artery and persistence of diastolic notching beyond 26 weeks of gestation was considered as abnormal and predisposing to high risk for development of Pregnancy induced hypertension and fetal growth restriction (6). In our study this has been found but umbilical artery doppler indices are found to be more sensitive than uterine artery doppler indices. It is concluded in our study, that increased values of doppler indices of uterine artery are associated with 40% of high risk pregnancies and 80% of them are associated with intrauterine growth retardation. Increased impedance to uterine artery blood flow was found in forty percent pregnancies with pre-eclampsia and about 20% of those who developed IUGR (7). Results are quite consistent with our studies. Thus our study highlighted the fact that abnormal Doppler results provide a better prediction of the more severe types of pregnancy complications. As pregnancy advances, gradually the uterine artery diameter enlarges, peak systolic velocity and volume flow rates increase and a progressive fall in impedance of blood flow occurs (8) which is also corroborating our findings.

There is a relationship between vasodilatation in middle cerebral artery and fetal hypoxemia that exist only in mild to moderate hypoxemia; with more severe degree of hypoxemia and academia, the value of PI reaches a nadir which has been suggested to represent the maximum vessel dilatation (9). In our study PI value of middle cerebral artery was found to be decreased with advancing gestational age in normal pregnancy and pregnancy induced hypertensives (usually the values were below 2S.D). This may be explained by the fact that fetal middle cerebral artery is a low resistance circulation throughout pregnancy. The mean values of all the doppler indices showed decline due to decrease in impedance in middle cerebral artery as fetus responds to hypoxemia by accomplishing major circulatory changes of which the most prominent is redistribution of cardiac output in favour of myocardium and brain at the expense of viscera. This adaptation of fetus to the effect of hypoxia is called brain sparing effect (10).

Our study found that Doppler studies of multiple vessels in the fetoplacental circulation can help in the monitoring of compromised fetus. A significant difference was found in between the Doppler indices of the three vessels (Umbilical, Uterine & Middle cerebral artery) in the study and the control group which is in agreement with other study.

Conclusion

Triple vessel color Doppler sonography is very useful in high risk pregnancy diagnosis and in predicting perinatal outcome. Thus it is concluded that color doppler can detect changes in fetoplacental and uteroplacental circulation which correlate strongly with the fetal growth and therefore associated with pregnancy outcome. Doppler velocimetry is very helpful in predicting high risk pregnancies with intrauterine growth retardation and timely recognition of fetal compromise to enable appropriate intervention and to prevent further complication.
Limitations of the study

This sample size is small due to non-availability of subjects as PIH is not a very common clinical entity and also color Doppler test is a very expensive test. But we will try to get more subjects in future to have some more wonderful results.

References