

## ASSESSMENT OF FOETAL COMPROMISE BY DOPPLER ULTRASOUND INVESTIGATION OF THE FOETAL CIRCULATION

Bindu Philip<sup>1</sup>, Shirly Kurian<sup>2</sup>

<sup>1</sup>Associate Professor, Department of Obstetrics and Gynaecology, Mount Zion Medical College, Chayalode, Adoor, Kerala.

<sup>2</sup>Assistant Professor, Department of Obstetrics and Gynaecology, Mount Zion Medical College, Chayalode, Adoor, Kerala.

---

### ABSTRACT

---

#### BACKGROUND

The condition in which the foetus does not reach its growth potential is called Intrauterine Growth Restricted (IUGR). The mothers who are generally healthy and well nourished, the incidence of IUGR is 3-5%. The incidence of IUGR is 15-20% or higher in a women population with hypertension or previous growth restricted foetus.

The aim of the study is to assess foetal compromise by Doppler ultrasound investigation of the foetal circulation.

#### MATERIALS AND METHODS

This study is a prospective study conducted between November 2013 to November 2016 in the Department of Radiodiagnosis and imaging of Mount Zion Medical College, Kerala. A total of 50 singleton pregnancies with suspected IUGR pregnancy attending the outpatient ward of Obstetrics and Gynaecology.

Inclusion Criteria- Pregnancies from 29 weeks to 42 weeks of gestation complicated by intrauterine growth restriction and who are ultrasound confirmed. In the first trimester, gestational age determination was estimated by history of menstruation or biometry of foetus.

Exclusion Criteria- Patients who had multiple gestations, congenital anomalies and history of membranes rupture. All the patients in the study were subjected to clinical history in detail to assess the risk factors of IUGR pregnancy, biometry of ultrasound and amniotic fluid assessment followed by Doppler ultrasound evaluation of uterine arteries, umbilical artery, middle cerebral artery, descending foetal thoracic aorta, ductus venosus and umbilical vein.

#### RESULTS

Majority of the patients were in the age group of 21-24 years. All the patients were in the age group of 19-30 years. 45% of antenatal mothers examined were between 28-31 weeks of gestational age, 35% were between 32-36 weeks of gestation, 20% were between 37-42 weeks of gestation age. 15 antenatal mothers had elevated uterine artery resistance index (30%), 12 antenatal mothers had persistent early diagnostic notch (24%), 11 antenatal mothers had elevated systolic/diastolic ratio (22%), 12 antenatal mothers had elevated uterine artery pulsatility index (24%), 15 antenatal mothers had elevated umbilical artery pulsatility index (30%), 10 antenatal mothers had elevated resistance index (20%) and 25 antenatal mothers had elevated systolic/diastolic ratio (50%). 8 (16%) foetus showed absence of end-diastolic flow in the umbilical artery flow velocity and 2 (4%) had reversal of end-diastolic flow in the umbilical artery flow velocity with a total of 10 (20%) foetuses having abnormal waveforms. There were 5 cases of intrauterine deaths, out of which 3 had absence of diastolic flow and 2 had reverse diastolic flow. Decreased pulsatility index of foetal middle cerebral artery was in 22 (44%) foetus, normal pulsatility index of foetal middle cerebral artery was in 28 (56%) foetuses. Elevated pulsatility index of descending thoracic aorta was in 26 (52%) foetuses, normal pulsatility index of descending thoracic aorta was in 24 (48%) of foetuses. Umbilical vein and ductus venosus Doppler study showed that 20 (40%) of the foetuses had presence of pulsatile flow in the umbilical vein flow velocity waveform and 30 (60%) showed absence of pulsatile flow. There were 5 intrauterine deaths and 45 livebirths. Of the 45 livebirths, 10 neonates were admitted in ICU, 10 neonates had 5 mins. Apgar score of less than 7. 11 foetuses had at least one adverse perinatal outcome, remaining 14 foetuses had favourable conditions.

#### CONCLUSION

After changes in arteries, early changes in veins is observed, which results in poor perinatal outcomes with increased risk of foetal mortality. Hence, Doppler investigation of the foetal venous circulation play an important role in monitoring the redistributing growth retarded foetus and thereby may help to determine the optimal time for delivery.

#### KEYWORDS

Foetal Compromise, Doppler, Foetal Circulation.

---

**HOW TO CITE THIS ARTICLE:** Philip B, Kurian S. et al. Assessment of foetal compromise by Doppler ultrasound investigation of the foetal circulation. J. Evid. Based Med. Healthc. 2017; 4(74), 4364-4367. DOI: 10.18410/jebmh/2017/869

---

*Financial or Other, Competing Interest: None.*  
*Submission 12-08-2017, Peer Review 20-08-2017,*  
*Acceptance 06-09-2017, Published 12-09-2017.*  
**Corresponding Author:**  
 Dr. Bindu Philip,  
 Vadakekkara House, Kaipattor P. O.,  
 Pathanamthitta District, Kerala, India.  
 E-mail: binduphilip123@gmail.com  
 DOI: 10.18410/jebmh/2017/869



**BACKGROUND**

The condition in which the foetus does not reach its growth potential is called Intrauterine Growth Restriction (IUGR). The mothers who are generally healthy and well nourished, the incidence of IUGR is 3-5%. The incidence of IUGR is 15-20% or higher in a women population with hypertension or previous growth restricted foetus. The most common cause of IUGR was placental insufficiency, which maybe primary or secondary due to infection of foetus, anomalies of foetal chromosome and disorders of maternal.

For normal pregnancy, the development of good uteroplacental circulation is required. To achieve this, many changes occur in foetal, placental and maternal vasculature. Abnormal vascular resistance patterns are developed, which may lead to compromise of foetal wellbeing with a 6-10 times higher risk of perinatal morbidity, mortality and impaired neurodevelopment when the above-mentioned mechanism fails. To prevent the occurrence of IUGR in high-risk pregnancies and also to deliver the foetuses already afflicted with growth restriction before they suffer the ill effects of hypoxia is the aim of foetal medicine. The opportunity for repetitive noninvasive haemodynamic monitoring in pregnancy was provided by Doppler ultrasound. To assess the uteroplacental, fetoplacental blood circulation and blood circulation of foetus, it became possible by Doppler ultrasound. Placental vascularity is provided by utero and fetoplacental circulation and the foetal response to hypoxia is provided by Doppler ultrasound.<sup>1</sup>

**MATERIALS AND METHODS**

This study is a prospective study conducted between November 2013 to November 2016 in the Department of Radiodiagnosis and imaging of Mount Zion Medical College, Kerala. A total of 50 singleton pregnancies with suspected IUGR pregnancy attending the outpatient ward of Obstetrics and Gynaecology.

**Inclusion Criteria-** Pregnancies from 29 weeks to 42 weeks of gestation complicated by intrauterine growth restriction and who are ultrasound confirmed. In the first trimester, gestational age determination was estimated by history of menstruation or biometry of foetus.

**Exclusion Criteria-** Patients who had multiple gestations, congenital anomalies and history of membranes rupture. All the patients in the study were subjected to clinical history in detail to assess the risk factors of IUGR pregnancy,

biometry of ultrasound and amniotic fluid assessment followed by Doppler ultrasound evaluation of uterine arteries, umbilical artery, middle cerebral artery, descending foetal thoracic aorta, ductus venous and umbilical vein.<sup>2</sup>

**RESULTS**

Age Group	Females	Percentage
19-20	10	20
21-22	15	30
23-24	15	30
25-30	10	20

**Table 1. Shows the Age Distribution**

Table 1 shows that the majority of the patients were in the age group of 21-24 years. All the patients were in the age group of 19-30 years.

Gestational Age	Percentage
28-31 weeks	45
32-36 weeks	35
37-42 weeks	20

**Table 2. Shows Gestational Age of Antenatal Mothers**

Table 2 shows that 45% of antenatal mothers examined were between 28-31 weeks of gestational age, 35% were between 32-36 weeks of gestation and 20% were between 37-42 weeks of gestation age.

Doppler Study	No. of Patients	Percentage
Elevated artery resistance index	15	30
Persistent early diagnostic notch	12	24
Elevated systolic/diastolic ratio	11	22
Elevated uterine artery pulsatility index	12	24

**Table 3. Shows Uterine Artery Doppler Study**

Table 3 shows that 15 antenatal mothers had elevated uterine artery resistance index (30%), 12 antenatal mothers had persistent early diagnostic notch (24%), 11 antenatal mothers had elevated systolic/diastolic ratio (22%) and 12 antenatal mothers had elevated uterine artery pulsatility index (24%).

Doppler Study	No. of Patients	Percentage
Elevated umbilical artery pulsatility index	15	30
Elevated resistance index	10	20
Elevated systolic/diastolic ratio	25	50

**Table 4. Shows Umbilical Artery Doppler Study**

Table 4 shows that 15 antenatal mothers had elevated umbilical artery pulsatility index (30%), 10 antenatal mothers had elevated resistance index (20%) and 25 antenatal mothers had elevated systolic/diastolic ratio (50%). 8 (16%) foetus showed absence of end-diastolic flow in the umbilical artery flow velocity and 2 (4%) had

reversal of end-diastolic flow in the umbilical artery flow velocity with a total of 10 (20%) fetuses having abnormal waveforms. There were 5 cases of intrauterine deaths, out of which 3 had absence of diastolic flow and 2 had reverse diastolic flow.<sup>3</sup>

<b>Foetal Middle Cerebral Artery Doppler study</b>	<b>No. of Patients</b>	<b>%</b>
Decreased pulsatility index	22	44
Normal pulsatility index	28	56
<b>Descending Thoracic Aorta</b>	<b>No. of patients</b>	<b>%</b>
Elevated pulsatility index	26	52
Normal pulsatility index	24	48

**Table 5. Shows Foetal Middle Cerebral Artery Doppler Study and Descending Thoracic Aorta**

Table 5 shows that decreased pulsatility index of foetal middle cerebral artery was in 22 (44%) foetus, normal pulsatility index of foetal middle cerebral artery was in 28 (56%) fetuses, elevated pulsatility index of descending thoracic aorta was in 26 (52%) fetuses and normal pulsatility index of descending thoracic aorta was in 24 (48%) of fetuses. Umbilical vein and ductus venos Doppler study showed that 20 (40%) of the fetuses had presence of pulsatile flow in the umbilical vein flow velocity waveform and 30 (60%) showed absence of pulsatile flow. There were 5 intrauterine deaths and 45 livebirths. Of the 45 livebirths, 10 neonates were admitted in ICU, 10 neonates had 5 mins. Apgar score of less than 7. 11 fetuses had at least one adverse perinatal outcome, remaining 14 fetuses had favourable conditions.

## DISCUSSION

Many studies have been reported regarding assessment of foetal compromise by Doppler ultrasound investigation of the foetal circulation. Singh K et al<sup>4</sup> conducted a study to determine and compare the diagnostic performance of various Doppler indices and flow velocity waveforms of fetoplacental, uteroplacental and foetal circulations as predictors of adverse perinatal outcome in clinically suspected IUGR pregnancy. 30 singleton pregnancies beyond 28 weeks of gestation with clinically suspected IUGR were included in the study. All the patients were prospectively examined with Doppler ultrasound of uterine arteries, umbilical artery, middle cerebral artery, foetal descending thoracic aorta, ductus venos and umbilical vein. The findings revealed 3 intrauterine deaths and 27 livebirths. Of the 27 livebirths, 7 were admitted to NICU (Neonatal Intensive Care Unit), 7 neonates had 5 mins. Apgar score of less than 7. Pulsatile index ratio of MCA/UMBA is the most sensitive index (89.5%) in predicting perinatal outcome. Presence of absence or reversal of diastolic flow in the umbilical artery, 'a' wave in ductus venos and pulsatile flow in the umbilical vein are ominous signs carrying grave prognosis. This study concluded that poor perinatal outcome can be anticipated with early changes noted in the arteries followed by the venous changes. Hecher K et al<sup>5</sup> conducted a study whose aim was to evaluate the significance of changes in foetal venous blood flow waveforms in high-risk pregnancies and

to investigate the time relation between alterations in venous and arterial Doppler waveform indices in compromised fetuses. The cross-sectional study consisted of 108 high-risk singleton pregnancies between 23 and 42 weeks' gestation without foetal chromosomal abnormalities or major malformations. Blood flow velocity waveforms were recorded from the umbilical arteries, descending thoracic aorta, middle cerebral artery, tricuspid and mitral ventricular inflow, ductus venos inferior vena cava and the right hepatic vein. The mean velocity and pulsatility index were calculated for arterial vessels, the E/A ratio for atrioventricular blood flow and peak forward velocities during ventricular systole and early diastole. The lowest forward velocity or peak reverse velocity during arterial contraction and time-averaged maximum velocity for venous vessels. Two ratios for venous waveforms, one of which is the equivalent of the pulsatility index were calculated. Foetal biophysical assessment was based on a computerised cardiotocogram and the biophysical profile score. The compromised group consisted of 37 fetuses delivered by caesarean section for an abnormal heart rate trace (n=21) or severe preeclampsia (n=9) or which died in utero (n=7) within 10 days of their last Doppler investigation. This group showed significant alterations in arterial and venous flow velocity waveforms, but not in atrioventricular inflow. Additionally, to find out whether venous Doppler investigation may help to detect a worsening of the situation in fetuses already showing arterial blood flow redistribution, we analysed the data of these fetuses separately. The 41 fetuses that had an aorta/middle cerebral artery pulsatility index ratio >95th percentile were divided into compromised and non-compromised groups according to their biophysical assessment and whether or not they developed foetal distress (caesarean section for abnormal heart rate trace or intrauterine death). The mean values for Doppler parameters of the compromised groups differed significantly from the non-compromised groups in all venous vessels, whereas differences on the arterial side were much less pronounced. Velocity ratios of venous waveforms were significantly higher and absent or reverse flow in the ductus venos with atrial contraction indicated a poor prognosis with a perinatal mortality of 5 out of 8. Foetal compromise is associated with significant alterations in the foetal arterial and venous circulation. Significant changes in venous Doppler waveforms develop due to increased afterload and perhaps myocardial failure in late deterioration after foetal arterial redistribution is established and seem to be closely related to abnormal biophysical assessment findings. Therefore, Doppler investigation of the foetal venous circulation may play an important role in monitoring the redistributing growth retarded foetus and thereby may help to determine the optimal time for delivery. Ranjan K Sahoo et al<sup>6</sup> conducted a study in which IUGR babies have got abnormal foetal biometry and Doppler variables. However, foetal biometry has got interobserver variability. In umbilical artery, S/D ratio, PI and RI of IUGR fetuses were significantly higher

than that of normal fetuses ( $4.03 \pm 0.15$  vs.  $1.99 \pm 0.493$ ;  $p < 0.01$ ,  $1.334 \pm 0.37$  vs.  $0.736 \pm 0.17$ ;  $p < 0.01$ ,  $0.753 \pm 0.151$  vs.  $0.482 \pm 0.109$ ;  $p < 0.01$ ). In middle cerebral artery, RI of IUGR fetuses was significantly lower than that of normal fetuses ( $0.0598 \pm 0.12$  vs.  $0.0742 \pm 0.129$ ;  $p < 0.01$ ). Cerebroplacental ratio (MCA RI/UA RI) of IUGR fetuses was significantly lower than that of normal fetuses ( $0.814 \pm 0.20$  vs.  $1.59 \pm 0.361$ ;  $p < 0.01$ ). MCA index (CPR < 1) shows highest sensitivity and productivity in diagnosing IUGR in comparison with other Doppler indices. Thus, CPR is a sensitive predictor of foetal growth retardation. However, HC/AC ratio has highest sensitivity and positive predictive value 67% among other non-Doppler parameter and has got more diagnostic value. Overall, no single non-Doppler sonographic parameter permits the confident diagnosis of IUGR. Multiple Doppler and conventional sonographic parameters shows increased sensitivity and predictivity than single parameter in the study group. Combined sonographic and Doppler parameters such as low EFW and SDR > 2SD as well as CPR < 1 and low EFW have better sensitive and predictive value. K. Harrington et al<sup>7</sup> conducted a study to observe the longitudinal changes in growth and associated Doppler measurements of the foetal circulation in pregnancies with a normal outcome and those complicated by preeclampsia, birth of a small for gestational age baby or a combination of these complications. Two hundred and ninety two women had serial ultrasound scans performed from the 24<sup>th</sup> week of pregnancy. Measurements obtained included- the abdominal circumference, umbilical artery pulsatility index, the middle cerebral artery pulsatility index and time-averaged velocity, and the thoracic aorta pulsatility index and time-averaged velocity. Outcome measures included the birth of a small for gestational age infant, preeclampsia or a combination of these complications. One hundred and sixty seven pregnancies ended in the normal birth of an appropriately grown infant at term, while 105 had a complicated outcome. They were divided into three categories- preeclampsia only (i.e., with the birth of an appropriately grown foetus, n=13); small for gestational age only with no evidence of preeclampsia, n=55; and preeclampsia complicated by the birth of a small for gestational age infant, n=37. The group with preeclampsia complicated by small for gestational age was closest in characteristics to true clinical intrauterine growth restriction. A reduction in the abdominal circumference mirrored a rise in the umbilical artery pulsatility index and preceded changes in the middle cerebral artery and thoracic aorta. The greatest degree of change in the foetal

circulation was observed during the three weeks preceding delivery. Ratios of the values obtained from the foetal and umbilical circulation demonstrated the greatest deviation from normal. A reduction in foetal growth velocity preceded changes observed in the foetal circulation. Ratios of the foetal Doppler parameters provided the clearest evidence of deterioration in the foetal condition. The information provided maybe of use in the diagnosis and management of the growth-restricted foetus.

## CONCLUSION

After changes in arteries, early changes in veins is observed, which results in poor perinatal outcomes with increased risk of foetal mortality. Hence, Doppler investigation of the foetal venous circulation may play an important role in monitoring the redistributing growth retarded foetus and thereby may help to determine the optimal time for delivery.

## REFERENCES

- [1] Baschat AA, Gembruch U, Reiss I, et al. Relationship between arterial and venous Doppler and perinatal outcome in foetal growth restriction. *Ultrasound Obstet Gynecol* 2000;16(5):407-413.
- [2] Divon MY. Umbilical artery Doppler velocimetry: clinical utility in high risk pregnancies. *Am J Obstet Gynecol* 1996;174(1 Pt 1):10-4.
- [3] Mari G, Deter RL. Middle cerebral artery flow velocity waveforms in normal and small-for-gestational-age fetuses. *Am J Obstet Gynecol* 1992;166(4):1262-1270.
- [4] Singh K, Sehgal P, Thukral CL, et al. Assessment of foetal compromise by Doppler investigation of placental vasculature, foetal arterial and venous blood flow. *International Journal of Gynaec Plastic Surgery* 2013;5(2):23-29.
- [5] Hecher K, Campbell S, Doyle P, et al. Assessment of foetal compromise by Doppler ultrasound investigation of the foetal circulation. Arterial, intracardiac, and venous blood flow velocity studies. *Circulation* 1995;91(1):129-138.
- [6] Sahoo RK, Nayak S, Panda SK, et al. Doppler assessment of the foetus with intrauterine growth restriction. *Int J Pharm Sci Rev Res Article No* 28, 2015;32(1):162-170.
- [7] Harrington K, Thompson M0, Carpenter RG, et al. Doppler foetal circulation in pregnancies complicated by pre-eclampsia or delivery of a small for gestational age baby: 2. Longitudinal analysis. *BJOG* 1999;106(5):453-466.