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## Original Research Article

# Umbilical artery Doppler indices in relation to fetal outcome in high risk pregnancy

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## ABSTRACT

**Background:** Umbilical artery Doppler indices in relation to fetal outcome in high risk pregnancy. The aim of this study was to study the umbilical artery Doppler velocimetry in predicting the fetal outcome in high risk pregnancy. This is a prospective study done over a period of 1 year in Silchar Medical College and Hospital from 1<sup>st</sup> September 2011 to 31<sup>st</sup> August 2012. 100 women with singleton pregnancy with high risk admitted in SMCH were subjected to umbilical artery Doppler along with morphology and biometry scan after fulfilling the inclusion and exclusion criteria.

**Methods:** 100 women with high risk pregnancy were evaluated by umbilical artery velocimetry between 28 and 41 weeks of pregnancy. Outcome of pregnancy was recorded for the normal Doppler group (n = 79; 79%), the low-end diastolic flow group (n = 19; 19%) and the group with absent/reversed diastolic flow (n = 2; 2%).

**Results:** Mothers with abnormal velocimetry had more number of caesarean sections than those with normal velocimetry. The diagnosis to delivery interval, gestational age at delivery and average birth weight were comparatively lower with higher incidence of admission to neonatal intensive care unit in foetuses with abnormal umbilical Doppler velocimetry. Sensitivity, specificity, positive and negative predictive values of Doppler for detecting abnormal fetal outcome were 43%, 83%, 33% and 88% respectively. Statistical analysis used: sensitivity, specificity and predictive values.

**Conclusions:** Fetuses with normal flow velocimetry are at lower risk than those with abnormal velocimetry in terms of poor Apgar score and neonatal intensive care admission. The average birth weight of the neonates with abnormal Doppler studies was lower than that of neonates with normal velocimetry. Doppler velocimetry studies of umbilical artery can provide the obstetrician important information regarding fetal wellbeing to help him improve fetal outcome.

**Keywords:** Doppler velocimetry, High risk pregnancy, Umbilical artery

## INTRODUCTION

The development of a good utero-placental circulation is essential for achievement of a normal pregnancy. Intrauterine growth retardation (IUGR) is associated with an increased risk of perinatal mortality, morbidity, and impaired neurodevelopment. The correct detection of the

compromised IUGR fetus to allow for timely intervention is a main objective of antenatal care. The most common methods for evaluating health in foetuses identified as SGA are the biophysical profile (BPP) and the non-stress test (NST). Unfortunately, neither of these tests is particularly sensitive for predicting poor outcome in IUGR pregnancies.

It is here that role of Color Doppler comes to detect these abnormal vascular resistance patterns. The important issue is not the identification of small fetus, but rather the "fetus at risk" for compromise.

Doppler assessment of the placental circulation plays an important role in screening for impaired placentation and its complications of pre-eclampsia, intrauterine growth restriction and perinatal death. Assessment of the fetal circulation is essential in the better understanding of the patho-physiology of a wide range of pathological pregnancies and their clinical management.

Early screening for Preeclampsia may allow vigilant antenatal surveillance and appropriate timing of fetal delivery in order to avoid serious sequelae. Various hemodynamic and biochemical measures have been found to have limited accuracy as screening measures for this condition.<sup>1,2</sup>

Placental insufficiency is the primary cause (60%) of intrauterine growth restriction in normally formed fetuses and can be identified using umbilical artery Doppler velocimetry.<sup>3</sup> Umbilical artery Doppler waveforms provide an estimate of downstream placental vascular resistance and placental blood flow. There is a strong association between reduced end-diastolic umbilical artery blood flow velocity and increased vascular resistance in the umbilical placental microcirculation. As well, abnormal umbilical artery Doppler waveforms have been associated with an increased risk of fetal acidosis.

The association between abnormal umbilical artery Doppler velocimetry and adverse pregnancy outcomes has been investigated widely.<sup>4,5</sup> Many reports have shown a statistically significant relation between increased fetoplacental resistance, as estimated by either the resistance index or systolic-diastolic ratio (S/D), and the later development of either preeclampsia or fetal growth retardation (FGR).<sup>6,7</sup> Despite these statistically significant correlations, the clinical utility of umbilical artery Doppler studies has been questioned because of its low predictive values for either preeclampsia or FGR and other adverse outcome in low risk population.<sup>8,9</sup>

In the present study, we determined whether umbilical artery Doppler velocimetry can predict perinatal outcomes in high risk pregnancies between 28 and 42 gestational weeks.

## METHODS

This is a prospective study done over a period of 1 year in Silchar Medical College and Hospital from 1<sup>st</sup> September 2011 to 31<sup>st</sup> August 2012. 100 women with singleton pregnancy with high risk admitted in SMCH were subjected to umbilical artery Doppler along with morphology and biometry scan after fulfilling the inclusion and exclusion criteria. Pregnancies beyond 30 weeks of gestation complicated by severe pre-eclampsia

and intrauterine growth restriction or both were selected. Gestational age determination was based on a best estimate from menstrual history, clinical gestational age or fetal biometry preferably in the first trimester or early second trimester. Pregnancies with multiple gestations and congenital anomalies were excluded from the study. Severe pre-eclampsia is defined according to the standard criteria of uncontrolled blood pressure, proteinuria and ultrasound parameters of intrauterine growth restriction. Other pregnancy complications like gestational diabetes mellitus are also included if associated with severe preeclampsia or intrauterine growth restriction was diagnosed based on ultrasound parameters with estimated fetal weight being less than 10<sup>th</sup> percentile for gestational age (SGA).

Data collected by Philips HD11 XE colour Doppler machine with convex probe 3.5 MHz. With Ultrasonography fetal biometry and morphology scan was done, then Doppler mode was switched on. Then transducer is placed over anterior abdominal wall over the uterus and is carefully manipulated till a free loop of umbilical cord seen by Grey scale imaging and colour was used to identify the umbilical artery. Thus, Doppler waveform was obtained. Parameters studied are S/D ratio and RI in umbilical artery. The flow velocity waveforms were considered abnormal if S/D ratio, RI exceeds 95<sup>th</sup> centile and if there is absent and reverse end diastolic flow.

For the purpose of analysis, the study population was distributed in three groups: a normal Doppler group, a diminished end-diastolic flow group and, an absent diastole or reversed diastolic flow group. These patients were followed up till delivery and details of pregnancy events, labour and delivery and neonatal outcome were noted. The abnormal pregnancy outcomes considered IUGR (<10<sup>th</sup> percentile birth rate for that gestational age). Perinatal outcomes considered are IUD, stillborn, gestational age at birth, birth weight, Apgar score at 5 minutes, admission to neonatal intensive care unit, need for positive pressure ventilation and neonatal mortality.

## Statistical analysis

These data collected from the study will be analyzed using sensitivities, specificity and predictive value.

## RESULTS

The present study was carried out on 100 women with singleton pregnancy with high risk pregnancies admitted in the department of obstetrics and gynaecology, Silchar Medical College and Hospital during the period of September 2011 to August 2012.

Among the 100 women studied, 21 pregnancies had abnormal Doppler waveforms in umbilical arteries. Doppler waveform of the umbilical artery was considered abnormal if S/D ratio and Resistance index (RI) exceeds

**Table 1: Maternal obstetrical history of study population. (n=100).**

|                          | Normal doppler<br>n=79 (79%) | Abnormal doppler<br>n=21 (21%) |
|--------------------------|------------------------------|--------------------------------|
| Maternal age (mean)      | 26.7 years                   | 29.5 years                     |
| <b>Parity</b>            |                              |                                |
| Primigravida             | 46 (58%)                     | 14 (66%)                       |
| Multigravida             | 33 (42%)                     | 7 (33%)                        |
| Past h/o of SGA          | 2 (2.5%)                     | 2 (9.5%)                       |
| Past h/o of PIH          | 3 (3.7%)                     | 2 (9.5%)                       |
| Past h/o perinatal death | 3 (3.7%)                     | 1 (4.7%)                       |

95<sup>th</sup> percentile or if there is absent or reverse end diastolic flow in the fetuses above the gestational age of 28 weeks. The mean for S/D ratio and RI for normal group (n=79) was 2.96 and 0.69 respectively, and for higher S/D and RI group (n=19) was 3.79 and 0.76 respectively (Table 3). In addition, 2 fetuses had absent end diastolic flow.

Small for gestational age babies with abnormal umbilical artery waveform had shorter diagnosis to delivery interval (9.6 days) than those with normal Doppler (Table 2). These fetuses with abnormal umbilical artery Doppler waveforms are at an increased risk for oligohydramnios (Table 3) and for delivery at a lower gestational age.

**Table 2: Neonatal outcome in study population.**

|                                    | Normal doppler<br>N = 79 (79%) | Abnormal doppler<br>N= 21 (21 %)   |  |
|------------------------------------|--------------------------------|------------------------------------|--|
|                                    |                                | Low end diastolic flow N=19, (19%) | Absent /reverse diastolic flow N=2, (2%) |
| Delivery at <36 weeks of gestation | N = 12 (15.1%)                 | N = 4 (21%)                        | N = 2 (100%)                             |
| Diagnosis to delivery interval     | NA                             | 9.6 days                           | <1 day                                   |
| Average birth weight               | 2867.08 g                      | 2294.73 g                          | 1500 g                                   |
| NICU admission                     | N = 29 (36.7%)                 | N =17 (89.4%)                      | -  |
| Average stay in NICU               | 0.91 days                      | 4 days                             | -  |
| Apgar <7 at 5 min                  | N =7 (8.8%)                    | N = 5 (26.3%)                      | N = 2 (100%)                             |
| Sex                                |                                |                                    |  |
| Female                             | 44                             | 10                                 | 2  |
| Male                               | 35                             | 9                                  | -  |

**Table 3: Antenatal characteristics of study population (n= 100).**

|                       | Normal doppler<br>N = 79, (79%) | Abnormal doppler N = 21, (21 %)       |  |
|-----------------------|---------------------------------|---------------------------------------|--|
|                       |                                 | Low end diastolic flow. N = 19, (19%) | Absent / reverse diastolic flow. N=2, (2%) |
| Mean s/d ratio        | 2.9659                          | 3.7957                                | --   |
| Mean RI               | 0.6925                          | 0.7636                                | --   |
| PIH/Pre-eclampsia     | 52 (65.8%)                      | 15 (78.9%)                            | 2 (100%)                                   |
| Diabetes              | --                              | 1 (5.2%)                              | --   |
| Severe anaemia        | 13 (16.4%)                      | 2 (10.5%)                             | 1 (50%)                                    |
| IUGR, oligohydramnios | 11 (13.9%)                      | 11 (57.8%)                            | 2 (100%)                                   |

The total fetuses delivered at less than 36 weeks gestation were 12 (15.1%) in normal Doppler group, 4 (21%) in low-end diastolic velocity group and 2 (100%) in the group with absent/reversed end diastolic velocity (Table 2). Frequently the fetuses in the abnormal Doppler group were delivered by caesarean section than those with normal Doppler velocimetry. These neonates had lower birth weight percentiles with higher perinatal asphyxia in terms of lower Apgar score which was below 7 at birth.

Babies with abnormal umbilical artery Doppler studies were more than twice as likely to be admitted to the neonatal intensive care unit and spent longer time there (Table 2). Overall 36.7% (n=29) of small for gestational

age babies with normal umbilical artery Doppler studies were admitted to neonatal intensive care unit (NICU) in contrast to 89.4% (n=17) small for gestational age babies with low-end diastolic velocity on umbilical artery Doppler.

### **Maternal characteristics**

There was no major difference in maternal age and parity between mothers with small for gestational age babies of normal umbilical artery velocimetry and those with abnormal umbilical artery velocimetry studies. There was a trend for more underlying medical problems in mothers with abnormal Doppler studies. The obstetric history

suggested a higher incidence of small for gestational age babies and pregnancy induced hypertension in previous pregnancies of the mothers of the abnormal Doppler group (Table 1).

They had high incidence of pregnancy induced hypertension, diabetes mellitus and severe anaemia developing during the pregnancy (Table 3). 78.9% (n = 15) fetuses with low-end diastolic velocity and 100% (n =

2) with absent / reversed diastolic flow were associated with maternal gestational hypertension.

However, the mothers of small for gestational age babies with normal umbilical artery Doppler studies also had a high incidence of 65.8% (n=52) pregnancy induced hypertension. Oligohydramnios was associated with pregnancy induced hypertension which constituted 57.8% of abnormal Doppler studies (Table 3).

**Table 4: umbilical artery doppler in predicting IUGR.**

| Doppler test           | True positive | False negative | False positive | True negative | Sensitivity | Specificity | Positive predictive value | Negative predictive value |
|------------------------|---------------|----------------|----------------|---------------|-------------|-------------|---------------------------|---------------------------|
| Combined S/D ratio, RI | 7             | 9              | 14             | 70            | 43%         | 83%         | 33%                       | 88%                       |

## DISCUSSION

In this study umbilical artery Doppler studies were performed in all high-risk pregnancies, this helped us to predict foetal morbidity and mortality in the abnormal umbilical artery Doppler group.

It has been shown by Rochelson BL, and various workers that perinatal morbidity and mortality were significantly greater in small for gestational age babies with abnormal umbilical artery Doppler studies than in those with normal studies.<sup>10-13</sup>

In the present study group there is significant decrease in S/D and RI of umbilical artery as birth weight increases, the birth weight being higher in the normal Doppler group (2867 gm) and lowest in the absent/ reversed end diastolic flow group (1500 gm).

This is in accordance with Fleischer et al who demonstrated that those fetuses with lower birth weight (<25<sup>th</sup> percentile) had higher placental vascular resistance than those with higher birth weight (>25<sup>th</sup> percentile).<sup>6</sup> In a study done by Malhotra et al birth weight in abnormal Doppler group was 742±126 gm and in normal Doppler group was 1680±259 gm.<sup>14</sup>

Berkowitz GS et al and various studies have reported on the association of abnormal umbilical artery velocity waveforms with fetal growth restriction and its prediction. Alfievic et al published a systematic review with the meta-analysis addressing the usefulness of Doppler in the surveillance of high-risk pregnancies.<sup>15,16</sup> Two groups of high-risk pregnant patients were identified and allocated to either a standard fetal assessment protocol or to standard fetal assessment plus Doppler ultrasound testing. Their results showed a decrease in perinatal mortality in the second group. The use of Doppler reduced the odds for perinatal death by as much as 38% (95% CI 15-

55%). However, it has also been shown that the use of Doppler in low-risk population confers no benefits over standard fetal surveillance.<sup>17</sup>

In the fetuses demonstrating IUGR, a characteristic adaptive vascular mechanism is the cornerstone for fetal survival, this change in the normal vascular physiology and distribution of blood flow is now very well characterized. The identification of a pattern demonstrating fetal adaptation to impaired uteroplacental blood flow constitutes the fetuses affected by IUGR.<sup>19</sup> Abnormal umbilical artery (UA) Doppler findings have proven useful in distinguishing the constitutionally small and healthy fetus from the fetus with IUGR.

In the present study out of 100 women, 2 small for gestational age fetuses studied, presented with head and abdominal circumference below their reference range, the pregnancy was complicated by oligohydramnios and PIH. These fetuses had absent diastolic flow in umbilical artery, and 1 of them was diagnosed intrauterine death 10 hrs later. Another fetus was born after 14 hours vaginally but turned to be fresh stillborn.

The results shown in Table 2 reveal that fetuses with abnormal umbilical artery velocimetry have a shorter diagnosis of abnormal Doppler to delivery interval, early delivery, decreased birth weight, increased NICU admissions and duration of stay there and with low Apgar scores than those with normal Doppler. Various workers have noticed in fetuses with abnormal umbilical artery Doppler velocimetry a similar poor perinatal outcome.<sup>10,12,19,14,15</sup> There are old reports suggesting that Doppler studies of velocity waveforms of the umbilical artery are more useful in identifying fetuses prone for IUGR than sonographic estimation of fetal weight.<sup>20,21</sup>

Similarly, our present results showed that there was a significantly increased incidence of neonatal death and

duration of admission for NICU care in preterm SGA infants with umbilical artery absent/reversed end diastolic flow. 36.7% of babies with normal Doppler had NICU admission and stayed for average of 1 day, compared to 89.4% among babies with abnormal Doppler, average days of stay in NICU were 4.

S/D ratio and RI of umbilical artery was significantly higher in those fetuses that had Apgar <7 than those who had Apgar >7 (Table 2). This shows a higher umbilical vascular resistance and therefore, a decreased placental perfusion in those who had low Apgar at birth.

The mean S/D ratio of umbilical artery was 2.95 in those babies who remained with the mother after delivery as compared to 3.14 in those who got transferred to NICU in the normal umbilical artery Doppler group. On the other hand, in the low end diastolic flow group, the mean S/D ratio of umbilical artery in those babies who remained with their mothers was 3.33 as compared to 3.57 in those admitted to NICU.

In consonance with present study the recent work of Vergani et al found that in fetal growth restricted cases delivered at or beyond 34 weeks gestation with abnormal umbilical artery velocimetry, it independently predicts the likelihood of admission to the NICU for reasons other than low birth weight alone.<sup>22</sup> Conversely, the study of 2 found that the effect of abnormal umbilical artery Doppler was not important in terms of admission of the newborn to the nursery, birth weight, and gestational age.<sup>19</sup> The results of present study show that fetuses with abnormal umbilical artery velocimetry have early delivery (at less than 36 weeks of gestation (21% versus 15.1%), increased NICU admission (89.4% versus 36.7%), low Apgar score (26.3% versus 8.8%) than those with normal Doppler. Various workers have noticed in fetuses with abnormal umbilical artery Doppler velocimetry, a similar poor perinatal outcome.<sup>19,23,24</sup>

Mothers of small for gestational age babies with abnormal Doppler studies were more likely to have history of obstetric complications in the previous pregnancy as observed by McCown et al.<sup>19</sup> They had high incidence of delivering small for gestational age babies, gestational hypertension, and history of perinatal death in the previous pregnancy.

These mothers of small for gestational age babies with abnormal umbilical artery Doppler velocimetry frequently delivered by caesarean section (42.8% versus 35.4%) for fetal distress with subsequent low Apgar scores and greater need for NICU admission than those with normal Doppler as was also noticed by Seyam et al. and Rochelson et al.<sup>23,13</sup>

Perinatal mortality was highest in the absent/ reversed end diastolic flow group. 1 fresh still birth and 1 intrauterine death occurred in this group. Whereas there was no perinatal death in normal Doppler group.

Various studies also suggest that in the most extreme waveform abnormality, there is REDF or AEDF which is considered a very ominous sign of placental compromise and is associated with high perinatal mortality rates.

Madazli et al also studied the severely growth restricted fetuses with AEDF and found a perinatal mortality of 40%.<sup>25</sup> Brodzski et al analyzed the outcome of 44 fetuses with REDF and found a perinatal mortality of 59%.<sup>24</sup>

In a study on the role of umbilical artery Doppler to predict adverse perinatal outcome in women with pre-eclampsia Yoon et al.<sup>26</sup> reported, that when gestational age at birth and pre-eclampsia were controlled for, an abnormal umbilical artery Doppler study was still a significant independent predictor of adverse perinatal outcome.

**Table 5: Comparison of study at SMCH with previous studies for IUGR with umbilical artery Doppler.**

| Study                      | Year | Outcome measures                  | Sensitivity | Specificity | Positive predictive value | Negative predictive value |
|----------------------------|------|-----------------------------------|-------------|-------------|---------------------------|---------------------------|
| Fleischer et al            | 1985 | IUGR <10 <sup>th</sup> percentile | 78          | 85          | --                        | --                        |
| Beattie and Dorman et al   | 1989 | IUGR <10 <sup>th</sup> percentile | 40          | 84          | --                        | --                        |
| Kofinas et al.             | 1991 | IUGR <10 <sup>th</sup> percentile | 71          | 93          | 83                        | 90                        |
| Atkinson Et al             | 1994 | IUGR <10 <sup>th</sup> percentile | 18          | 91          | 13                        | 94                        |
| Pharuhas Chanprapaph et al | 1995 | IUGR <10 <sup>th</sup> percentile | 53          | 78          | 74                        | 65                        |
| Trudinger BJ et al.        | 2005 | IUGR <10 <sup>th</sup> percentile | 34          | 93          | 75                        | 70                        |
| Present study              | 2011 | IUGR <10 <sup>th</sup> percentile | 43          | 83          | 33                        | 88                        |

Present study underlines the existence of a strict correlation between umbilical Doppler velocimetry and an increased incidence of perinatal complications in

IUGR fetuses, in consonance with the study of Soregaroli et al.<sup>27</sup> Similar results were drawn by Baschat et al when they looked at the umbilical artery resistance to determine



if it can help improve the accuracy of diagnosing IUGR and help in identifying a small fetus at risk of chronic hypoxemia.<sup>28</sup>

Recent meta-analysis of randomized controlled trials suggests that incorporation of umbilical artery Doppler waveform analysis into management protocols for intrauterine growth restricted fetuses significantly decreased perinatal mortality.<sup>29</sup>

Baschat et al provided clear evidence to support that antenatal surveillance is unnecessary despite Ultrasonography findings consistent with or diagnostic of IUGR if both umbilical artery S/D ratio and the amniotic fluid volume are normal.<sup>28</sup> However, they noticed that commonly, complications occurred to those fetuses with abnormal Doppler studies, which correlates with our study as in Table 2. It is reasonable to assume that decreased uteroplacental perfusion during uterine contractions is likely to further jeopardize gaseous exchange in fetuses with pre-existing abnormal umbilical artery velocimetry.

Hecher et al have pointed out the role of venous Doppler studies in assessing the degree of hypoxemia and in guiding the correct time for delivery.<sup>30</sup> The fetuses with absent diastole/reversed diastolic flow on follow up have sequelae of neurological deficit in high proportions.

Out of 21 patients with abnormal umbilical artery Doppler 5 patients developed IUGR with a sensitivity of 43% for both SD and RI. It is similar to opinion by Dorman B et al.<sup>31</sup> Sensitivity of absent diastolic flow was 100% (Table 5).

The present result revealed a low sensitivity of S/D ratio and RI (43 %) for IUGR detection similar to the studies of Berkowitz and Anyaegbunam, but, different from the studies of Fleischer and Divon, which revealed a sensitivity as high as 78-87%.<sup>15,32,6,11</sup> The discrepancy of research methodology and the characteristics of the studied population may be the important factors leading to the different result. Furthermore, the intra-observer variation and the different location of the Doppler measurement might contribute to the error variance. In addition, the standard criteria of birth weight less than 10<sup>th</sup> percentile is controversial because it does not make a distinction among fetuses who are constitutionally small, growth restricted and small, and growth restricted but not small. The constitutionally small fetuses are not at high risk and have no rising of fetoplacental vascular impedance.

Thus, the misclassification of a normally nourished, healthy, but constitutionally small, neonate as growth restricted may reduce the sensitivity of the test. However, the relatively high specificity of 83% and negative predictive value of 88% in the present study also provide suggestive evidence that the umbilical artery S/D ratio and RI may be appropriate for confirmation rather than

early detection of IUGR. Nevertheless, the present study has clearly shown the usefulness of the umbilical artery S/D ratio and RI as a non-invasive back up technique that ensures fetal wellbeing.

The value of Doppler velocimetry assessment has been extensively studied for a high-risk pregnancy. It has been proven to significantly reduce perinatal death and lower unnecessary induction of labour in preterm IUGR fetuses as described in a meta-analysis of these trials. Suspicious small fetuses with abnormal Doppler velocimetry require intensive monitoring and possible intervention. However, the perinatal outcome and proper management of IUGR fetuses with normal Doppler remain obscure. Further study in this aspect would be very encouraging and useful.

## CONCLUSION

From the results of this study, we could conclude that the absent/reversed end diastolic flow, as detected by antenatal umbilical artery Doppler is associated with increased risk for poor perinatal outcome.

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