



## Assessment of Uterine Artery Umbilical Artery and Fetal MCA Doppler Velocimetry as Predictors of Adverse Outcome in Pregnancies Complicated by Third Trimester Oligohydramnios

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#### ABSTRACT

To assess uterine, umbilical and fetal MCA artery Doppler velocimetry as potential indicators of adverse outcomes in pregnancies complicated by third trimester oligohydramnios and to determine which Doppler indicators are more important and useful in identifying fetuses that might have adverse outcomes. This is an observational correlational clinical study conducted over a period of 6 months from August 2023 to January 2024. This study included all booked single live intrauterine gestation more than 24 weeks with oligohydramnios (i.e. AFI<5 cm and borderline AFI <5-8 cm) referred to the Department of Radiology for routine antenatal check-up and all patients referred from Department of Obstetrics and Gynecology on the clinical suspicion of oligohydramnios in the third trimester. Pregnancies complicated by fetal anomalies, premature rupture of membrane, diabetes, hypertension, Rh incompatibility were excluded from this study. Thirty pregnant women in total were examined. After obtaining informed written consent, routine antenatal scan was performed and any fetuses with congenital anomalies were excluded from the study. For all patients, baseline investigations like hemoglobin percentage, urine examination, blood typing, NST and BPP were performed. The amniotic fluid volume was calculated using the four quadrant AFI technique. Oligohydramnios was defined as AFI <5 cm and borderline oligohydramnios was defined as AFI 5-8 cm. Doppler indices were obtained for the umbilical artery, both uterine arteries and fetal MCA. Then patients were followed up according to the Doppler findings and AFI. Patients with oligohydramnios and normal Doppler were followed up every two weeks. Patients with abnormal Doppler were followed up every week till delivery. In patients with followed up Doppler, the last Doppler study prior to delivery was taken into consideration. All patients were followed up until delivery with NST, FMC and BPP and treated with L-Arginine, oral rehydration and bed rest. Gestational age at the time of delivery, mode of delivery, fetal distress during normal delivery, nature of amniotic fluid, indication for caesarean section, APGAR at 1 and 3 minutes, birth weight and NICU admission were considered as the adverse outcome measures. AFI <5 cm and AFI 5-8 cm in third trimester of pregnancy are both associated with adverse outcomes with severe oligohydramnios having increased incidence than borderline oligohydramnios. In identifying adverse outcomes, the presence of diastolic notch has the highest specificity and positive predictive value in the uterine artery while RI, PI and S/D ratio in the umbilical artery have good sensitivity, specificity, positive and negative predictive values with good accuracy. The cerebro-placental ratio has the highest sensitivity, specificity, positive and negative predictive values with an accuracy of 56.67% among the MCA indices. Uterine artery, umbilical artery and fetal MCA Doppler velocimetry are all associated with increased incidence of adverse outcomes in both severe and borderline oligohydramnios. An abnormal study of all three vessels has the highest incidence of IUGR and NICU admission. We also found that adverse outcomes can still occur even if the Doppler of one vessel is abnormal and the other two are normal. Thus from our study, we conclude that for third trimester oligohydramnios, Doppler velocimetry of uterine, umbilical and fetal MCA together serve as good indicators of fetuses at risk of developing adverse outcomes for prompt management.

## INTRODUCTION

Amniotic fluid has a major role in the development of the fetus. It serves as a medium to provide nutrients to the fetus, permits the fetus to move freely, cushions the fetus from external injuries as well as the umbilical cord from compression. It also helps to maintain a constant temperature and also has a bacteriostatic action, which helps to prevent onset of infections. Quantitative and qualitative alterations of the amniotic fluid complicate 7% of the pregnancies. Polyhydramnios complicates 1-3% while oligohydramnios involves 3-5% of the pregnancies<sup>[1]</sup>. Traditionally, oligohydramnios has been implemented as a sign of potential fetal compromise and associated with an increased incidence of adverse perinatal morbidity and mortality. Although its aetiology can be multifactorial, the major factor is thought to reflect uteroplacental insufficiency with chronic fetal hypoxia which can be depicted using sonography of foetuses<sup>[2]</sup>. Doppler ultrasound is a non-invasive technique that is used to evaluate maternal and fetal hemodynamics. The utero-placental circulation can be assessed by velocimetry of the uterine arteries<sup>[2,3]</sup>.

The purpose of this study is to establish the predictive value of Doppler velocimetry in identifying pregnancies complicated with oligohydramnios that are at increased risk of developing adverse perinatal outcomes to ensure a heightened regimen of antenatal surveillance and management to reduce the incidence of further compromise and identify cases that may require prompt termination.

### Objectives:

- To assess uterine, umbilical and fetal MCA artery Doppler velocimetry as potential indicators of adverse outcomes in pregnancies complicated by third trimester oligohydramnios
- To determine which Doppler indicators are more important and useful in identifying fetuses that might have adverse outcomes

## MATERIALS AND METHODS

This is an observational correlational clinical study conducted over a period of 6 months from August 2023 to January 2024. This study included all booked single live intrauterine gestation >24 weeks with oligohydramnios (i.e. AFI <5 cm and borderline AFI <5-8 cm) referred to the Department of Radiology for routine antenatal check-up and all patients referred from Department of Obstetrics and Gynecology on the clinical suspicion of oligohydramnios in the third trimester. Pregnancies complicated by fetal anomalies, premature rupture of membrane, diabetes, hypertension, Rh incompatibility were excluded from this study. Thirty pregnant women in total were examined.

After obtaining informed written consent, routine antenatal scan was performed and any fetuses with congenital anomalies were excluded from the study. For all patients, baseline investigations like haemoglobin percentage, urine examination, blood typing, NST and BPP were performed. The amniotic fluid volume was calculated using the four quadrant AFI technique. Oligohydramnios was defined as AFI <5 cm and borderline oligohydramnios was defined as AFI 5-8cm. Doppler indices were obtained for the umbilical artery, both uterine arteries and fetal MCA. Then patients were followed up according to the Doppler findings and AFI. Patients with oligohydramnios and normal Doppler were followed up every two weeks. Patients with abnormal Doppler were followed up every week till delivery. In patients with followed up Doppler, the last Doppler study prior to delivery was taken into consideration. All patients were followed up until delivery with NST, FMC and BPP and treated with L-Arginine, oral rehydration and bed rest.

Gestational age at the time of delivery, mode of delivery, fetal distress during normal delivery, nature of amniotic fluid, indication for caesarean section, APGAR at 1 and 3 mins, birth weight and NICU admission were considered as the adverse outcome measures.

**Imaging Technique:** All ultrasound studies were performed on Philips AFFINITY 50 AND Philips AFFINITY 70 machine. The patient was put in a recumbent position. Using a C6-2 MHz convex transducer and after excluding fetal congenital anomalies, the fetal biometry was first calculated to assess growth for gestational age. The amniotic fluid index was then calculated using the four quadrant AFI technique as described by Phelan. The maternal abdomen was divided into four quadrants using the umbilicus and linea nigra as reference points for the upper and lower halves and for the left and right halves respectively. The deepest vertical pocket of amniotic fluid in each quadrant that was free from fetal parts and umbilical cord and with the width > 5 mm was identified in real time imaging and image was frozen. Care was taken to keep the ultrasound transducer parallel to the maternal sagittal plane and perpendicular to the maternal coronal plane at all times. The pocket of amniotic fluid in each quadrant was measured in a strictly vertical direction using the in-built calliper. The AFI was calculated as a sum total of the amniotic fluid in each of the four quadrants. Oligohydramnios was described when AFI <5cm and borderline oligohydramnios was described when AFI 5-8cm.

Following this Pulsed wave Doppler study was done in semi recumbent position for the umbilical artery, both uterine arteries and fetal MCA. All the recordings were obtained during the absence of fetal movements and respiration. The angle of insonation

was kept below 60 degrees at all times and a sample volume of 2-4 mm was used. The uterine artery was evaluated bilaterally. The arteries were sampled just distal to the point where they crossed the external iliac vessels. When a clear wave form was obtained, image was frozen and using the callipers in auto- calculation mode the PI, RI, S/D ratio and presence or absence of diastolic notch were noted. The RI was considered to be abnormal if the value was >95th percentile of previously published values for gestational age<sup>[4]</sup>. The PI was considered abnormal if the value was >95th percentile of previously published values for gestational age<sup>[5]</sup>. The S/D ratio was considered abnormal if the value was >2.6. Presence of diastolic notch in one or both the arteries was considered abnormal.

For the umbilical artery, the transducer was placed over the anterior abdominal wall and a free loop of cord was identified by grey scale imaging. Colour Doppler was switched on to identify umbilical artery. Spectral Doppler was used and Doppler wave form was recorded. Using the callipers in auto-calculation mode the PI, RI, S/D ratio and presence or absence or reversal of end diastolic flow was noted. The PI, RI and S/D ratio were considered abnormal if >95th percentile of previously published value for gestational age<sup>[6]</sup>. Absent or reversed end diastolic flow was also considered as abnormal. Next, the fetal MCA was evaluated by first obtaining transverse image of the fetal head at the level of the sphenoid bones. Colour flow was used to display the Circle of Willis. The MCA was identified as the antero-lateral branch running from the Circle of Willis. The MCA in the near field was insonated at about 1.0cm distal to its origin from internal carotid artery, spectral Doppler applied and Doppler wave form was obtained. Using the callipers in auto-calculation mode, the RI, PI, S/D ratio were calculated. The cerebro-placental ratio (MCA PI / UA PI) was then manually calculated. The RI and PI were considered abnormal if <5th percentile for gestational age. The S/D ratio was considered abnormal if lesser than that for gestational age. The MCA PI / UA PI ratio is usually constant during the last 10 week of gestation. As reported by Wladimiroff *et al.*<sup>[7]</sup>, it is possible to use a single cut off value of 1.08 after 30 weeks of gestation. Based on this, MCA PI/UA PI was considered abnormal if <1.08.

All data was entered into a Data Collection Proforma Sheet (Appendix I) and were entered into Excel (MS Excel 2011). The data was exported and analysed using SPSS v25. Percentages or mean and standard deviations were computed for baseline characteristics. Comparisons of categorical data were done using Chi-square test. The corresponding P values were found to determine the level of significance.  $p < 0.05$  was considered statistically significant.

## RESULTS AND DISCUSSIONS

### Prenatal and Postpartum Characteristics of Pregnancies Complicated by Third Trimester Oligohydramnios:

Mean (Standard deviation) age of the study participant ( $n = 30$ ) was  $26.40 \pm 5.40$  and majority i.e. 20 (66.7%) of them were booked primigravida with minimum primary school education belonging to upper lower socio-economic status at 33-36 weeks of gestational age at the time of delivery. Most of the study participants underwent radiological examination around 33-36 weeks of gestational age of which 46.7% of the study participants had Oligohydramnios i.e. AFI < 5 while the others had borderline Oligohydramnios i.e., AFI between 5-8. Majority of the study participants delivered by LSCS after induction at term i.e. between 37 to 40 years. Fetal distress (47.1%), severe oligohydramnios (23.5%), Previous LSCS (17.6%), Cephalopelvic disproportion (5.9%) and placenta praevia (5.9%) were the indication for LSCS.

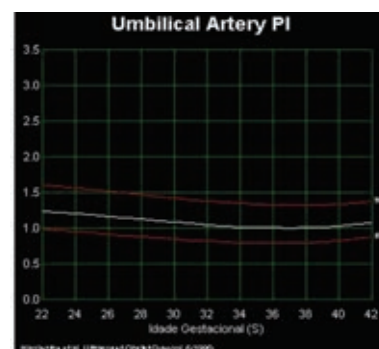


Fig. 1: Graph showing normal PI values for Umbilical artery according to gestational age

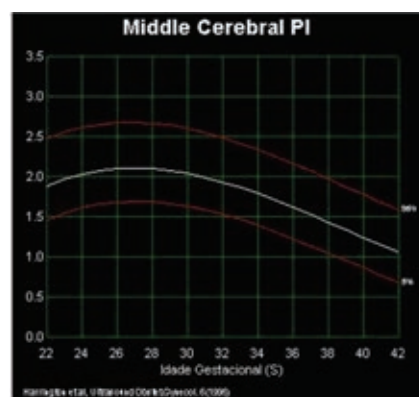


Fig. 2: Graph showing normal PI values for MCA according to gestational age.

### Adverse Neonatal Outcomes in Pregnancies Complicated by Third Trimester Oligohydramnios:

There was one still birth among women complicated with severe oligohydramnios. Most of the babies were delivered at term (90%) with APGAR score more than 7 (90%) at 1 and 3 mins. Birth weight of the neonates

**Table 1: Arterial Indices of Uterine arteries, umbilical artery and fetal MCA**

Variables	Categories	No. of patients (n=30)	Percentage
Abnormal Uterine artery Indices	RI>95th percentile	9	30.0
	PI>95th percentile	8	26.7
	Persistent diastolic notch	6	20.0
	S/D ratio >2.6	8	26.7
Uterine Artery Doppler	Normal	19	63.3
	Abnormal	11	36.7
Abnormal Umbilical artery Indices	RI>95th percentile	8	26.7
	PI>95th percentile	8	26.7
	Absence EDV	1	3.3
	S/D ratio >95th percentile	8	26.7
Umbilical Artery Doppler	Normal	22	73.3
	Abnormal	8	26.7
Abnormal MCA artery Indices	RI <5th percentile	5	16.7
	PI <5th percentile	8	26.7
	S/D LESS THAN GA	6	20.0
	MCA/UA PI<1.08	7	23.3
MCA Doppler	Normal	17	56.7
	Abnormal	13	43.3

**Table 2: Comparison of outcome variables according to status of uterine artery Doppler**

Variables	Uterine Artery		p-value
	Normal (n=19)	Abnormal (n = 11)	
Fetal weight <10th percentile	6(31.5%)	8(72.7%)	0.029*
IUGR	5(26.3%)	8(72.7%)	0.023*
Induction of Labour	9(47.4%)	7(63.6%)	0.345
LSCS for fetal distress	4(21.1%)	7(63.6%)	0.047*
Preterm delivery	1(5.3%)	1(9.1%)	1.000
Apgar score <7	0	0	-
NICU admission	6(31.5%)	5(45.5%)	0.696
PN death	1(5.3%)	0	1.000

**Table 3: Comparison of outcome variables according to status of Umbilical and fetal MCA artery Doppler**

Variables	Umbilical Artery		p-value	MCA artery		p-value
	Normal (n=22)	Abnormal (n=8)		Normal (n = 17)	Abnormal (n = 13)	
Fetal weight < 10th percentile	9(40.9%)	5(62.5%)	0.417	9(52.9%)	5(38.5%)	0.431
IUGR	8(36.4%)	5(62.5%)	0.242	8(47.1%)	5(38.5%)	0.721
Induction of Labour	12(54.5%)	4(50.0%)	0.273	11(64.7%)	5(38.5%)	0.363
LSCS for fetal distress	6(27.3%)	5(62.5%)	0.104	5(29.4%)	6(46.2%)	0.346
Preterm delivery	0	2(25.0%)	0.064+	0	2(15.4%)	0.179
APGAR score <7	0	0	-	0	0	-
NICU admission	7(31.8%)	4(50.0%)	0.417	6(35.3%)	5(38.5%)	0.858
PN death	0	1(12.5%)	0.267	0	1(7.7%)	0.433

were equally distributed i.e. <10th percentile (46.7%) and >10th percentile (53.3%). Neonatal complications such as IUGR (43.3%), NICU admission (36.7%) and neonatal death (3.3%) were seen among the study participants.

#### **Doppler Study of the Both Uterine Arteries, Umbilical Artery and Fetal MCA:**

- Out of 30 patients, 9 patients (23.33%) had abnormal uterine Doppler velocimetry. Among these 9 patients, 5 patients (55.55%) had abnormal values in all four indices of uterine artery (RI, PI, S/D, diastolic notch). These patients had an increased incidence of IUGR, induction of labour, LSCS for fetal distress and NICU admission. One patient had preterm delivery and meconium-stained liquor
- Out of 30 patients, 8 patients (26.6%) had abnormal umbilical Doppler velocimetry. All these patients (100%) had abnormal values in all three indices (RI, PI, S/D). There was an increased incidence of LSCS for severe oligohydramnios,

LSCS for fetal distress, IUGR and NICU admission in all these patients. Three cases had induction of labour, 1 patient had meconium staining of liquor and 1 patient had preterm delivery

- Twelve out of 30 patients (40%) had an abnormal fetal MCA Doppler velocimetry. 83.3% of these patients had adverse outcomes with an increase in incidence of IUGR, NICU, LSCS and induction of labour. Two patients had meconium staining and preterm delivery. 25% of the 12 patients had abnormal values in all four indices of MCA (RI, PI, S/D and CPR). There was increased incidence of IUGR, NICU admission, preterm and LSCS for severe oligohydramnios
- Among 12 patients, 4 patients (33%) who had abnormal MCA Doppler velocimetry, the umbilical artery Doppler was normal, in other 4 patients the Doppler of all three arteries were abnormal and these cases had IUGR and NICU admission and the remaining 3 patients had abnormal Doppler of MCA and umbilical artery while uterine artery was normal. However, these patients also had perinatal adverse outcomes

**Comparison of Outcome Variables According to Status of Uterine, Umbilical and Fetal MCA Doppler:** In our study, 72.7% of patients with abnormal uterine artery Doppler (Table 1) had IUGR, 63.6% had labour induction, 63.6% had LSCS for foetal delivery, 9.1% had preterm delivery and 45.5% had NICU admission. In cases where the umbilical artery Doppler showed abnormalities (Table 2), 62.5% of cases resulted in IUGR, 50% in labour induction, 62.5% in LSCS for foetal distress, 25% in preterm delivery, 50% in NICU admission and 12.5% in postnatal mortality. It was found that about 38.5% of patients had IUGR, 38.5% had induced labour, 46.2% had LSCS for foetal distress, 15.4% had preterm delivery, 38.5% had NICU hospitalisation and 7.7% of patients experienced postnatal death when the MCA Doppler was abnormal (Table 3).

The estimation of AFI is an important part of antenatal scanning. The association of oligohydramnios with adverse perinatal outcomes has been proven with a multitude of studies available in literature. The use of Doppler velocimetry as an adjunct to routine management of cases diagnosed with oligohydramnios has shown to be quite effective in identifying fetuses at increased risk of developing adverse outcomes in the intrapartum and postpartum periods. Although many studies have utilised the fetoplacental or uteroplacental evaluation for identifying high risk pregnancies, no studies are available in literature that have employed uteroplacental and fetoplacental evaluation together in examination of oligohydramnios in third trimester.

Our study was conducted in 30 patients who were diagnosed with oligohydramnios in the third trimester of pregnancy and admitted to our hospital. We carried out the study to compare the usefulness of uterine artery, umbilical artery and fetal MCA Doppler velocimetry in predicting adverse perinatal outcomes in these patients. We then compared the outcome results with similar studies done in India as well as other countries. In our study, the mean gestational age was 26.40 which was slightly higher in comparison to Jagatia *et al.*<sup>[8]</sup> and Casey *et al.*<sup>[9]</sup> where the mean maternal age was 23.9 years. In our study, the maximum number of patients (40%) were in the 25-29 years age group and 36.7% in the 20-24 years age group which is comparable to Jagatia *et al.*<sup>[8]</sup>. In the study by Jandial *et al.*<sup>[8]</sup>, 67% were in the 20-25 years age group, 48% in 21-25 years age group and 23% in the 26-30 years age group. According to Jandial *et al.*<sup>[8]</sup> the mean gestational age at oligohydramnios was 34-36 weeks which is comparable with our study where the mean gestational age was 33.8 weeks. In the study by Casey *et al.*<sup>[9]</sup>, the mean gestational age

was slightly higher at 37.5 weeks. In our study, majority of the patients (66.7%) were primi gravida, which is comparable to Donald *et al.*<sup>[10]</sup> and Jandial *et al.*<sup>[11]</sup> where 60% were primi gravida. In our study 53.3% had borderline oligohydramnios and 46.7% had severe oligohydramnios while in the study by Ravikant *et al.*<sup>[12]</sup> 70% had borderline oligohydramnios and 30% had severe oligohydramnios. In the study by Jandial *et al.*<sup>[11]</sup> labour was spontaneous in 28%, induced in 58% and elective LSCS was done in 14%. In our study, 23.3% had spontaneous labour, 16% had induced labour and 23.3% were taken up for elective LSCS. In our study, 40% had normal vaginal delivery and 56.7% underwent LSCS which was comparable to that found in Jandial *et al.*<sup>[12]</sup> study, where 44% had vaginal delivery and 56% had LSCS.

In our study, in the severe oligohydramnios group, 92.8% had adverse outcomes. Meconium staining was seen in 7.1%, preterm delivery in 7.1%, IUGR in 50%, NICU admission in 28.5%, LSCS for fetal distress in 50%. No postnatal death was observed in this group. In our study, in the borderline oligohydramnios group, 75% had adverse outcomes. Meconium staining was seen in 12.5%, preterm delivery in 7.1%, IUGR in 37.5%, NICU admission in 43.75%, LSCS for fetal distress in 25% and postnatal death was seen in 6.25%. In the study by Ravikant *et al.*<sup>[12]</sup>, there was an increase in LSCS in borderline oligohydramnios than in severe oligohydramnios (90.48% vs. 40.82%). But in our study, there was increased LSCS in severe oligohydramnios than in borderline oligohydramnios. In our study, the mean birth weight was 2.32 kg. 46.7% had fetal weight <10th percentile for gestational age. In the study by Ravikant *et al.*<sup>[12]</sup> the mean birth weight was 2.33 kg which was comparable to our study. In our study, among those patients who underwent LSCS, 47.1% was for fetal distress and 23.5% was for severe oligohydramnios, while in the study by Ravikant *et al.*<sup>[12]</sup>, 20.52% was for fetal distress and 41.02% was for severe oligohydramnios. In comparison with Jandial *et al.*<sup>[12]</sup> and Ravikant *et al.*<sup>[12]</sup>, our study had lesser rates on Induction of labour, preterm delivery, abnormal FHR, Postnatal death and meconium staining. However, there was increased incidence of LSCS for fetal distress and NICU admission. IUGR was a little higher than that in Ravikant's<sup>[12]</sup> study, but lesser than that in Jandial<sup>[13]</sup> study. In Casey's study<sup>[9]</sup>, 42% had induction of labour and only 7% had NICU admission. Only 6.7% had an abnormal I min Apgar score and hence was lesser in comparison to other studies. In our study meconium staining was seen in a total of 10% of patients while 86.7% had clear meconium at the time of delivery. IUGR was seen in 43.3% of patients in our study, 36.7% had NICU admission and 3.3% had postnatal death of the baby.



## CONCLUSION

AFI <5cm and AFI 5-8cm in third trimester of pregnancy are both associated with adverse outcomes with severe oligohydramnios having increased incidence than borderline oligohydramnios. In identifying adverse outcomes, the presence of diastolic notch has the highest specificity and positive predictive value in the uterine artery while RI, PI and S/D ratio in the umbilical artery have good sensitivity, specificity, positive and negative predictive values with good accuracy. The cerebro-placental ratio has the highest sensitivity, specificity, positive and negative predictive values with an accuracy of 56.67% among the MCA indices. Uterine artery, umbilical artery and fetal MCA Doppler velocimetry are all associated with increased incidence of adverse outcomes in both severe and borderline oligohydramnios. An abnormal study of all three vessels has the highest incidence of IUGR and NICU admission. We also found that adverse outcomes can still occur even if the Doppler of one vessel is abnormal and the other two are normal. Thus from our study, we conclude that for third trimester oligohydramnios, Doppler velocimetry of uterine, umbilical and fetal MCA together serve as good indicators of fetuses at risk of developing adverse outcomes for prompt management.

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