

Umbilical Artery Doppler Ultrasonography in High Risk Pregnancy And Fetal Outcome

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ABSTRACT

Serial Doppler studies of the Umbilical Artery Resistance Index (UARI) were performed in 50 patients with singleton, high-risk pregnancy, between 28 weeks gestational age till delivery. There was a significant association between abnormal UARI and subsequent abnormal fetal outcome as evidenced by higher percentage of babies with low birthweight, IUGR, poor Apgar score and requiring SCN care. The perinatal mortality rate was 90.9 per 1000, which was five times higher than the overall statistics i.e. 16.7 per 1000. It was also associated with a higher chance of obstetric intervention by emergency Caesarean section.

In this study, UARI achieved a 100% specificity rate but the sensitivity was 47.8%. The positive predictive value was 100% and negative predictive value was 69%. All the patients with abnormal UARI had abnormal fetal outcome (zero false positive rate) and about third of patients with normal UARI have abnormal fetal outcome (31% false negative rate). We concluded that the umbilical artery flow velocity waveform (FVW) is an effective screening tool for detecting intrauterine compromise in high-risk pregnancies.

Keywords: *Doppler ultrasound, umbilical artery resistance index, flow velocity waveforms, high-risk pregnancy.*

INTRODUCTION

Over the past decades, as maternal risk in pregnancy has diminished, obstetric care has now turned and focused on the fetus and neonate. Correspondingly, as parents feel more secure about maternal safety, they increasingly expect a perfect outcome for their babies. Antepartum detection of the fetus at risks of death or damage in-utero remains a major challenge in modern obstetric practice. Until recently, electronic

fetal heart rate monitoring by cardiotocography has been a widely used method of assessing fetal wellbeing. Although this test predicts normal outcome reasonably well, it is less accurate in the prediction of poor neonatal outcome. It has a low false negative rate of 1% or less, and a high false positive rate of more than 75%^{1,2}.

In an attempt to improve antenatal care, other methods of fetal evaluation have emerged and among these is Doppler ultrasound. It provides a non-invasive method to study the fetal haemodynamics by assessing flow velocity waveforms (FVW) in blood vessels. Three major areas have been studied: the maternal uterine artery, the umbilical artery and the fetal circulation e.g. femoral, middle cerebral and renal artery. The umbilical artery has attracted most studies, probably due to the ease with which it can be identified with relatively cheap continuous wave Doppler equipment³.

The umbilical artery FVW reflects the presence of placental vascular resistance and the perfusion of the fetoplacental circulation. The use of umbilical artery FVW as a screening test has not been shown to be of value⁴. However, its value in the management of

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high-risk pregnancy is assured^{5,6}. There is strong association between abnormal FVW and adverse fetal outcome.

We undertake the study to test the validity of umbilical artery FVW in predicting abnormal fetal outcome in high-risk pregnancy. We hope that Doppler ultrasound will prove itself to be a reliable tool in antepartum fetal monitoring.

OBJECTIVES

1. To examine the relationship between ABNORMAL umbilical artery FVW in high-risk pregnancy and the subsequent fetal outcome.
2. To examine the relationship between NORMAL umbilical artery FVW in high-risk pregnancy and the subsequent fetal outcome.
3. To determine the profile of patients at risk of development abnormal FVW.

PATIENTS AND METHODS

During the 6 months study period, 50 patients with singleton pregnancy and having recognized high-risk factors (Table 1) were entered into the study. The gestational age was at least 28 weeks at the time of first study. The umbilical artery FVW was recorded using Doppler ultrasound with a continuous wave probe. Studies were performed in the absence of fetal breathing and in this study, the index used was Umbilical Artery Resistance Index (UARI). The UARI were then rated against the institutional normogram for gestational age between 28 and 42 weeks. An abnormal value was considered to be either an UARI exceeding the 95th percentile or the observation of absent or reversed end-diastolic flow.

Fetuses with normal UARI were retested on a 2 weekly interval until they reached 36 weeks gestation. Thereafter the tests were done weekly till delivery. Fetuses with abnormal UARI, regardless of the gestational age, were retested within 24 to 48 hours. Upon delivery the fetal outcome were examined and classified as either normal or abnormal. An abnormal fetal outcome included one or more of the followings:

- i. Five minute Apgar score ≤ 6
- ii. Admission to Special Care Nursery (SCN)
- iii. Intrauterine growth retardation (IUGR) of less than the tenth centile.
- iv. Perinatal death of an infant who weighed 500 gm or more up to the 28th day of age.

Patient details and FVW results were recorded prospectively on standard cards at the time of the Doppler Study and outcome details were entered on these cards at the time of delivery. Only the results of the last Doppler ultrasound examination were used for analysis. Calculations were done to determine the sensitivity, specificity, positive and negative predictive values for UARI. Chi-square was used for statistical analysis.

RESULTS AND DISCUSSION

Fifty patients were included in the study and they were assessed on 77 occasions. Eighteen patients had two or more studies performed. The gestational age at examination ranged from 28 weeks (first study) to 43 weeks (last study). The mean maternal age was 29.4 years, 18 of them being nuliparous and 32 were multiparous.

The distribution of patients was in accordance with the principal indication for Doppler as listed in Table 1. Most of them had more than one risk factor at initial referral.

Table 1: Principle Indication for Doppler Study

Indication	N	%
Hypertension	18	36
Postdates	10	20
Suspected IUGR	8	16
Diabetes Mellitus	5	10
Decreased fetal Movement	2	4
Bad Obstetric History	2	4
Others	5	10
Total	50	100

Table 2: Doppler Findings and Fetal Outcome

UARI	Fetal Outcome		Total
	Abnormal	Normal	
Abnormal	11(TP)	0(FP)	11
Normal	12(FN)	27(TN)	39
Abnormal	23	27	50

TP = True positive FP = False positive
 FN = False negative FP = True negative

Table 3: Validity of UARI

Sensitivity	47.8%
Specificity	100%
Positive predictive value	100%
Negative predictive value	69%

Table 4: Pregnancy Outcome as Related to UARI

Pregnancy Outcome	UARI		
	Total	Normal	Abnormal
No of Pregnancy	50	39	11
Mode of Delivery			
a) Vaginal	28	24 (61%)	4 (36%)
Spontaneous labour	17	14 (36%)	3 (27%)
Induced labour	11	10 (25%)	1 (9%)
b) Caesarean section	22	15 (39%)	7 (64%)
Elective	7	5 (13%)	2 (18%)
Emergency	15	10 (26%)	5 (46%)
Parity			
a) Nulliparous	18	12 (31%)	6 (55%)
b) Multiparous	32	27 (69%)	5 (45%)

Table 5: Fetal Outcome by Result of last Umbilical Artery FWV Study

Variables	Total	UARI	
		Normal	Abnormal
No of Pregnancies	50	39	11
Gestation at delivery (weeks)	38	38.8	35.1
Birth weight (g)	2873	3080	2139
Apgar score at 5 min \leq 6	5 (10%)	2 (5%)	3 (27%)*
SCN care	20 (40%)	11(28%)	9 (82%)**
IUGR	8 (16%)	3 (8%)	5 (45%***)
Perinatal Mortality (corrected)			
Number	2	1	1
Rate per 1000	40.0	25.6	90.9

Results shown are mean values or number (% of group) as appropriate. Significance of difference compared with the normal group, * P<0.05, **P<0.01, ***P<0.005 (Chi-square for categorical data).

Table 6: Indication for Study and Abnormal UARI

Indication	N	Abnormal UARI	%
Diabetes Mellitus	5	2	40
Suspected IUGR	8	3	38
Hypertension	18	5	28
Postdate	10	1	10
Decreased fetal movement	2	0	0
Bad Obstetric History	2	0	0
Others	5	0	0
Total	50	11	

Table 7: Abnormal UARI and Abnormal Fetal Outcome

Fetal Outcome	Abnormal UARI		
	>95 th Centile	Absent Diastolic Flow	Reversed Diastolic Flow
No of Pregnancy	8	2	1
Parity			
Nulliparous	4	1	1
Muiltparous	4	1	0
Emergency CS for fetal distress	2	2	1
Gestational at delivery (weeks)	36	33	29
Birth weight (g)	2470	1400	1000
Apgar score at 5 min. ≤ 6	1	1	1
SCN Care	6	2	1
IUGR	2	2	1
Perinatal Death	0	1	0

DOPPLER FINDINGS AND FETAL OUTCOME

Of the 50 patients referred for high-risk pregnancies, 11 of them (22%) had abnormal UARI during the last Doppler study. All of these pregnancies had abnormal fetal outcome (Table 2). In other words, the UARI had zero false positive rates. Nevertheless, of the 39 patients who had normal UARI, 12 of them had abnormal fetal outcome. This made the false negative rate to be 12/39 i.e. 30.8%.

By using the basic setup for the 2x2 table method, calculation was done for the sensitivity, specificity, positive and negative predictive values for UARI. Doppler study of UARI was highly specific but a less sensitive test (Table 3). These findings were rather different from result of Devoe's study⁷, where of the 1000 high risk pregnancies examined, the UARI sensitivity was just 20%, the positive predictive value was 50% and the negative predictive value was 85%. The only similarity was the high specificity value of 95%. That study also found that by combining Doppler study with non-stress test (CTG) or amniotic fluid volume, there was an improvement in the positive predictive value.

PREGNANCY OUTCOME AS RELATED TO UARI

Among the patients having normal UARI, 61% were delivered by vaginal route, and 39% by Caesarean section (Table 4). On the contrary, in patients with abnormal UARI, 64% underwent Caesarean section and the remaining 36% were delivered vaginally ($P < 0.25$ Non-significant). Of these 7 patients that had Caesarean section, 5 of them were done as emergency. In other words, patients with abnormal UARI had a higher incidence of abdominal delivery, most of which were done as emergency cases. Two out of five patients who had emergency Caesarean section were induced electively but ended up with Caesarean section due to intrapartum fetal distress.

FETAL OUTCOME BY RESULT OF LAST UMBILICAL ARTERY FVW STUDY

Further details of abnormal fetal outcome in relation to UARI study were illustrated in Table 5. Pregnancies with abnormal UARI had shorter gestation at delivery (mean POA 35 weeks) and gave lower birthweight babies (Mean birthweight 2139g). For pregnancies with normal UARI, the mean gestational age at delivery was 38.8 weeks and the birthweight 3080g. These findings were similar to Trudinger's study where the mean gestational age at delivery for patients with normal UARI was 38.3 weeks and mean birthweight was 3097g^{8,15}. The group with abnormal UARI had higher proportion for newborn that were growth retarded i.e. 45% ($P < 0.005$). In a preselected population of high risk pregnancies, especially those with small for gestation age fetuses, UARI has a high predictive value with regard to diagnosing fetal compromise and can be used for monitoring fetal health⁹.

The babies with abnormal UARI who had Apgar score of < 6 at 5 minutes and requiring SCN care outnumbered

those who had normal UARI ($P < 0.05$ and $P < 0.01$ respectively). The perinatal mortality rate between those with normal or abnormal UARI did not have any statistical difference ($P > 0.05$). Probably a bigger sample size would give a clearer picture. Many studies had shown that abnormal UARI especially the absent or reverse flow patterns were associated with higher perinatal mortality rate^{8,15}.

From this study we found that abnormal UARI was associated with significant adverse fetal outcome as assessed by Apgar score, SCN care and number of IUGR babies. However there was no significant relationship with perinatal mortality probably limited by the small sample size.

INDICATIONS FOR STUDY AND ABNORMAL UARI

In an attempt to determine the profile of patients at risk of developing abnormal FVW, it was found that two out of five (40%) patients with diabetes mellitus had abnormal UARI (table 6). Although there were only 5 patients with diabetes mellitus referred for the Doppler study, this group gave the highest percentage of abnormal UARI. The fact that only 5 patients with diabetes mellitus were included in this study suggested that the clinician might not take it as a strong indication for Doppler study.

This is obvious when comparing with the other 3 indications i.e. hypertension, IUGR and postdatism. Perhaps in future, fetal surveillance by Doppler should include more patients with diabetes mellitus. However, as the study was limited by its population size, it might not be applicable to all pregnancies. Oloffson et al reported a significantly higher umbilical artery pulsatility index in the fetuses of diabetic mothers that subsequently developed fetal distress in labour¹⁰. The role of Doppler study in diabetic pregnancy is still under research and there are still many uncertainties.

Many studies have examined the role of umbilical artery FVW in the suspected IUGR babies and pregnancy complicated by hypertension. Both the conditions are associated with placental vascular insufficiency, which are detectable by FVW. Small fetuses that have normal Doppler FVW do not appear to be at risk antenatally¹¹. Those with abnormal FVW have higher risk of perinatal death, antepartum and intrapartum fetal distress, operative delivery for fetal distress, admission to the neonatal intensive care unit and prolonged duration of hospitalization¹².

In this study, three out of eight patients with suspected IUGR babies had abnormal UARI. Upon delivery, these babies were confirmed to have restricted growth of less than the tenth centile and required further care in SCN. There was no severe morbidity or mortality. Out of these eight patients with suspected IUGR, three of them had normal UARI days before delivery but having adverse fetal outcome. Two of them had intrapartum fetal distress requiring emergency Caesarean section. This finding is not consistent with those observed by Trudinger⁸.

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Eighteen patients were referred for hypertensive disorder. Out of the five having abnormal UARI, four of them had pre-eclampsia. Of the thirteen patients having normal UARI, nine of them were non-proteinuric hypertension and they had normal fetal outcome. The other four were pre-eclamptic and had adverse fetal outcome. In this study there was an unusual proportion of false negative i.e. four out of eighteen patients who were pre-eclamptic had normal UARI but an abnormal fetal outcome. This was contrary to findings in other studies where the umbilical artery FVW appears to be predictive of adverse fetal outcome in hypertension in pregnancy^{13,14}. This again might be due to small sample size or the poor negative predictive value of Doppler Ultrasound.

ABNORMAL UARI AND ABNORMAL FETAL OUTCOME

There were 11 patients who had abnormal UARI and these were further divided into three groups: elevated UARI > 95th centile with positive end diastolic flow (PED, n=8), absent end diastolic flow (AED, n=2) and reversed end diastolic flow (RED, n=1). In this study, all the three patients with AED or RED were referred for pre-eclampsia complicated by IUGR. They required prompt delivery by Caesarean section. One of the babies with AED expired at 48 hours of life. The baby with RED survived but had multiple neurological deficits. Studies have found that pregnancies complicated by both IUGR and hypertension had a higher risk of developing AED and RED when comparing with the PED group, they had higher rate of SCN admission, perinatal mortality, cerebral haemorrhage, anaemia or hypoglycaemia¹⁵.

In this study there were two cases of perinatal mortality. The first case was a 27 years old primigravida who had severe pre-eclampsia and deteriorating renal function at 31 weeks. Doppler study showed absent end-diastolic flow. Emergency Caesarean section was done and delivered an IUGR baby of 1500g. There was evidence of concealed abruptio placentae. The baby expired

after 48 hours due to severe pulmonary haemorrhage.

The second patient was a multipara who had two previous early neonatal deaths due to sepsis. Both had uneventful antenatal period and delivered vaginally at term. During her third pregnancy, Group B Streptococcus was isolated in vaginal swab and treated accordingly. She had a normal fetal outcome. As for this pregnancy, Doppler study was done in view of her bad obstetric history. The UARI was normal. At birth, the baby weight 3100 gm and had good Apgar score. However, the baby became cyanosed at four hours of life and was treated as congenital pneumonia. The baby died 13 days later due to sepsis. As the cause of death is not related to a compromised fetoplacental circulation, FVW is therefore not the appropriate tool to detect such abnormal fetal outcome.

CONCLUSION

The present study describes the pregnancy outcome in 50 patients with high-risk profiles. There was a significant association between abnormal UARI and subsequent abnormal fetal outcome as evidenced by higher percentage of babies with low birthweight, IUGR, poor Apgar score and requiring SCN care. The perinatal mortality rate was 90.9 per 1000, which was five times higher than the overall statistics i.e. 16.7 per 1000¹⁶. It was also associated with a higher chance of obstetric intervention i.e. earlier delivery by emergency Caesarean section.

In this study, UARI achieved a 100% specificity rate but the sensitivity was less satisfactory (47.8%). The positive predictive value was 100% and negative predictive value was 69%. All patients with abnormal UARI had abnormal fetal outcome (zero false positive rate) and about one third of patients with normal UARI having abnormal fetal outcome (31% false negative rate). Based on this study, we could thus conclude that the umbilical artery FVW is an effective screening tool for detecting intrauterine compromise in high-risk pregnancies.

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