Original Article

Umbilical artery Doppler Velocimetry: A valuable tool for antenatal fetal surveillance?

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ABSTRACT:

Objective: To determine umbilical artery Doppler velocity parameter systolic: diastolic ratio (S/D ratio) relation with fetal well being and outcome.
Setting: Department of Obstetrics and Gynecology, Lady Willingdon Hospital, Lahore

Duration of study: Six months from 27-02-2008 to 26-08-2008.

Subjects and methods: Sixty patients fulfilling the inclusion criteria were included in this study. They were subdivided into two groups. Group 'A' included 30 normal pregnant women with no medical or obstetrical risk factors and group 'B' included 30 pregnant women having risk factors like, hypertension, diabetes, Rhesus incompatibility, discordant twins, intrauterine growth restriction and non immunehydropsfetalis.

Results: In comparison of S/D ratio with risk factors it was observed that S/D ratio ≤ 3 was present in 7 patients (11.6%) with hypertension/preeclampsia, 2 patients (3.3%) with diabetes, 1 patient (1.6%) with intrauterine growth restriction, 9 patients (15.0%) with oligohydramnios, no patient with twin pregnancy while S/D ratio >3 was present in 19 patients (31.6%) in pregnancy with hypertension/preeclampsia, 3 patients (5%) with diabetes mellitus, 11 patients (18.3%) with intrauterine growth restriction, 15 patients (25.0%) with oligohydramnios and only 1 patient (1.6%) with twin pregnancy. It was observed that women with S/D ratio ≤ 3, no neonate was observed with < 4 Apgar at 1 minute. 5 neonates (8.3%) had ≤ 6 Apgar score at five minute, 10 neonates (16.6%) needed resuscitation and 7 neonates (11.6%) were admitted to neonatal unit. On the other hand women with >3 S/D ratio delivered 10 neonates (16.6%) with <4 Apgar score at 1 minute, 23 (38.3%) with ≤ 6 score at 5 minutes and 23 neonates (38.3%) needed resuscitation, 21 (35.0%) were admitted to neonatal unit for asphyxia.

Conclusion: Umbilical artery Doppler studies is an integral tool while evaluating health of high risk pregnancies. However, it is not appropriate as a screening tool for low risk pregnancies.

Key words: Fetal surveillance, Doppler velocimetry, Intrauterine growth restriction.

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INTRODUCTION:

Doppler ultrasound has become an essential tool in antenatal fetal surveillance in recent years. It helps to identify and manage a compromised fetus in high risk pregnancies and is also used as a screening tool in low risk pregnancies. The main aim is to identify 'at risk' fetus in order to apply clinical intervention which could result in reduced perinatal morbidity and mortality [(1)].

Doppler studies of umbilical artery, uterine artery, middle cerebral artery, aorta, umbilical vein, ductusvenosus and inferior vena cava, systolic-diastolic (S/D) ratio of umbilical artery, and Absent or Reversed end diastolic flow A/REDF in umbilical artery provide an opportunity for early recognition and management of high risk pregnancies like pregnancy induced hypertension, chronic hypertension [2], pregnancy with diabetes [3], Rhesus incompatibility [4] and discordant twins.

Doppler study allows noninvasive assessment of utero-placental insufficiency and help in diagnosis and management of fetal growth restriction [5,6.] It also helps to differentiate a truly growth restricted fetus from the fetus that is constitutionally small but otherwise normal.

Doppler waveform of vessels is most commonly applied as S/D ratio (ratio of maximal systolic flow velocity to minimal end diastolic flow velocity). It provides an estimation of downstream resistance. During pregnancy the uterine and umbilical arteries maintain diastolic blood flow and normal placental bed is characterized by low resistance and high blood flow. Thus S/D ratio provides an indirect estimate of adequacy of blood flow to fetus. S/D ratio of umbilical artery decrease from about 4.0 at 20 weeks to about 2.0 at 40 weeks. Generally it is less than 3.0 after 30 weeks. Increased S/D ratio is found in maternal hypertension, poorly controlled insulin dependent diabetes, fetal growth restriction and placental insufficiency. The degree of abnormality in umbilical artery Doppler waveform correlates with risk of fetal hypoxia [7].

This study was designed to determine the correlation of S/D ratio of umbilical artery with timely recognition and management of fetuses in high risk pregnancies.

OBJECTIVE:

To determine umbilical artery Doppler velocity parameter systolic: diastolic ratio (S/D ratio) relation with fetal well being and outcome.

MATERIAL & METHODS:

This study was conducted at the Department of Obstetrics and Gynecology, Lady Willingdon Hospital, Lahore, during a period of six months from 27-02-2008 to 26-08-2008, after approval from Head of department of Obstetrics and Gynecology, Lady Willingdon Hospital, Lahore. Sample size was sixty and sampling technique was purposive non-probability sampling. After detailed explanation of designed study each pregnant woman eligible for the study as determined by inclusion and exclusion criteria, was asked to give written informed consent for participation. The study group consisted of thirty pregnant patients of all ages in their third trimester with risk factors(pregnancy induced hypertension, diabetes mellitus, twin pregnancy, rhesus incompatibility, non-immune hydropsfetalis and intrauterine growth restriction). Thirty pregnant women of all ages with no identified risk factor in their third trimester were recruited as controls .They were recruited from outpatient, emergency and antenatal department.

Inclusion and exclusion criteriae were set as: Pregnant women of all ages in third trimester with well-established gestational age by ultrasound, pregnancy with pregnancy induced hypertension, pregnancy with diabetes mellitus, twin pregnancy, rhesus incompatibility, non-immune hydropsfetalis and pregnancy with intrauterine growth restriction. Pregnant women with congenitally malformed fetus on ultrasonography were excluded. On the basis of purposive non-probability sampling they were divided into two groups. In group-A, 30 normal pregnant women and in group-B, 30 pregnant women with risk factor like hypertension, diabetes, Rhesus incompatibility, discordant twins, intrauterine growth restriction and non-immune hydropsfetalis.

Their demographic profile, name, age, and history recorded. History of index pregnancy was obtained in terms of LMP, duration of pregnancy, any complaints, if their severity, duration, aggravating and relieving factors. A detailed history of their identified risk factor (PIH, chronic hypertension, diabetes mellitus, growth restriction and discordant twin) in terms of duration, severity, symptoms, current and previous treatments was recorded. General physical examination followed by systemic and obstetric examination was conducted and recorded. Patients were investigated by the routine tests like complete blood examination, blood grouping and Rh factor, liver function test, renal function test, and specific

investigations like biophysical profile, and Doppler velocimetry.

Doppler velocimetric studies were performed between 32-36 weeks. They were managed accordingly and their outcome noted regarding mode of delivery, normal or caesarean section either done electively or in emergency.

Examination of baby just after delivery, APGAR score at 1 minute and at 5 minute after delivery was recorded. It was also noted that the baby required resuscitation or shifted to neonatal unit. All this information was collected through a proforma.

Data analysis

The data was analyzed using SPSS version 12.0. Descriptive statistics were used for variables, mentioning mean and standard deviation for numeric data. The routine investigations were presented as frequency tables in positive and negative proportions.

The outcome of the two techniques was compared for agreement and disagreement. The outcome was quantitative and qualitative in nature and tested for significance by t test and Chi square test. The p value ≤ 0.05 was taken as significant.

RESULTS:

A total of 60 patients were included during study period of six months from 27-02-2008 to 26-08-2008. They were divided into two groups. Group-A had thirty normal pregnant women without any risk factor and Group-B contained thirty pregnant women with risk factor like hypertension, diabetes, twin pregnancy and pregnancy with intrauterine growth restriction.

S/D ratio of umbilical artery was measured in both groups and fetal outcome in term of APGAR scores at one minute and 5 minute interval, neonatal resuscitation and admission to neonatal unit was noted.

While studying the distribution of cases by history of high blood pressure, it was found that in group-A, No patient while 25 patients (83.3%) in group-B had high blood pressure. Difference between two groups was statistically significant (P=0.001) (Table-1). History of diabetes revealed that no patient in group-A and 5 patients (16.7%) in group-B had diabetes (P=0.019) (Table-2).

History of intrauterine growth restriction in group-A was not found while in group-B, there were 12 patients (40.0%) with intrauterine growth restriction (P=0.002) (Table-3).

History of leaking per vaginum reported in 18 patients (60.0%) in group-A and in 2 patients (6.7%) from group-B (P<0.001) (Table-4).

History of decreased fetal movement was observed in 15 patients (50.0%) in group-A and 20 patients (66.7%) in group-B (P=0.190) (Table-5).

Distribution in term of presence of oligohydramnios, 9 patients (30.0%) in group-A and 15 patients (50.0%) in group-B had oligohydramnios (P=0.113) (Table-6).

Polyhydramnios was observed in 1 patient (3.3%) in goup-A and 3 patients (10.0%) in group-B (P=0.300) (Table-7).

Amniotic fluid index were increased in 1 patient (3.3%) in group-A and 2 patients (6.7%) in group-B (Table-8) (P=0.192).

Cardiotocography was reactive in 17 patients (56.7%) in group-A and 9 patients (30.0%) in group-B (Table-9) (P=0.037).

Distribution of cases by mode of delivery shows 15 patients (50%) in group-A, 7 patients (23.3%) in group-B delivered by spontaneous vaginal delivery, 13 patients (43.3%) in group-A and 22 patients (73.3%) in group-B delivered by caesarean section, 2 patients (6.7%) in group-A and 1 patient (3.3%) in group-B needed instrumental delivery (P=0.062) (Table-10).

Presence of meconium staining was noted in 1 patients (6.7%) in group-A and 10 patients (33.3%) in group-B (P=0.010) (Table-11).

Mean values of different investigations in group-A and B showed significant difference especially in terms of blood urea, serum uric acid, SGOT, SGPT, 24 hour urine protein, blood sugar fasting and S/D ratio of umbilical artery (Table-12).

S/D ratio ≤ 3 was noted in 27 patients (90.0%) in group-A and 6 patients (20.0%) in group-B while S/D ratio > 3 was observed in 3 patients (10.0%) in group-A and 24 patients (80.0%) in group-B (Table-13).

In comparison of S/D ratio with risk factors it was observed that S/D ratio ≤ 3 was present in 7 patients (11.6%) with hypertension/ preeclampsia, 2 patients (3.3%) with diabetes, 1 patient (1.6%) intrauterine growth restricted, 9 patients (15.0%) with oligohydramnios, no patient with twin pregnancy while S/D ratio >3 was present in 19 patients (31.6%) in pregnancy with hypertension/preeclampsia, 3 patients (5%) with diabetes mellitus, 11 patients (18.3%) with intrauterine growth restriction, 15 patients (25.0%) with oligohydramnios and only 1 patient (1.6%) with twin pregnancy. Difference between two groups was statistically significant.

Regarding mode of delivery in low risk group it was found that S/D ratio ≤3, 20 patients (74%) were delivered by spontaneous vaginal delivery and 4 patients (15%) by emergency caesarean section due to fetal distress and 3 patients (11%) by instrumental delivery. While with S/D ratio ≥3 only one patient (33%) was delivered by spontaneous vaginal delivery while 2 patients (66%) were delivered by emergency caesareansection. P value is highly significant. (Table 14 a)

Mode of delivery in high risk group S/D ratio ≤3, 3 patients(50%) were delivered by spontaneous vaginal delivery, 2 patients (33%) were deliveredby emergency caesarean section , 1 patient (16%) was delivered by forceps delivery. While with S/D >3 2 patients (8.3%) were delivered by spontaneous vaginal delivery and 20 patients(83.3%) by emergency caesarean section. And 2 patients(8.3%) by forceps delivery. This shows significant p value in high risk group.(Table 14b)

Regarding neonatal outcome in relation to S/D ratio in low risk group shows that patients with S/D ratio ≤3 seventeen babies (62%) were born with Apgar score > 7 at one minute after birth and one patient (3.7%) with Apgar score ≤5 at five minute interval eight babies (29.6%) need resuscitation and only baby (3.7%) was admitted to neonatal unit. While in

S/D ratio > 3,one baby (33.3%) was born with Apgar score ≤5 at five minute interval. One baby (33.3%) needs resuscitation and one (33.3%) needs admission to neonatal unit.(Table 15a)

Regarding S/D ≤3 ratio in high risk group, three babies (50%)wereborn with Apgar score < 7 at one minute interval and only one baby (16.6%) was born with Apgar score ≤ 5 at five minute interval. One baby (16.6%) needs resuscitation and one baby (16.6%) was referred to neonatal unit. In those with S/D ratio > 3, three babies (12.5%) were born with Apgar score > 7 at one minute interval. While eight babies (33.3%) were born with Apgar score ≤ 5 and eight babies (33.3%) need resuscitation, out of which five babies (20.8%) were admitted in neonatal unit and P value is highly significant. (Table 15b).

Table I: Distribution of cases by history of rise of blood pressure

n = 60

Rise of blood pressure	Group-A (Normal pregnant women) n = 30		Group-B (Pregnant women with risk factors) n = 30	
	No.	%	No.	%
Yes	-	-	25	83.3
No	30	100.0	05	16.7
Total	**30**	**100.0**	**30**	**100.0**

Chi Square = 42.86

P value = < 0.001

Table-2: Distribution of cases by history of diabetes
n = 60

History of Diabetes	Group-A (Normal pregnant women) n = 30		Group-B (Pregnant women with risk factors) n = 30	
	No.	%	No.	%
Yes	-	-	05	16.7
No	30	100.0	25	83.3
Total	**30**	**100.0**	**30**	**100.0**

Chi Square = 5.45
P value = 0.019

Table-3: Distribution of cases by history of intrauterine growth restriction

n = 60

History of intrauterine growth restriction	Group-A (Normal pregnant women) n = 30		Group-B (Pregnant women with risk factors) n = 30	
	No.	%	No.	%
Yes	-	-	12	40.0
No	30	100.0	18	60.0
Total	**30**	**100.0**	**30**	**100.0**

Chi Square = 15.00

Table-4: Distribution of cases by history of leaking per vaginum

n = 60

History of leaking per vaginum	Group-A (Normal pregnant women) n = 30		Group-B (Pregnant women with risk factors) n = 30	
	No.	%	No.	%
Yes	18	60.0	02	06.7
No	12	40.0	28	93.3
Total	**30**	**100.0**	**30**	**100.0**

P value = 0.0001
Chi Square = 19.00
P value = < 0.001

Table-5: Distribution of cases by history of decreased fetal movement

n = 60

History of decreased fetal movement	Group-A (Normal pregnant women) n = 30		Group-B (Pregnant women with risk factors) n = 30	
	No.	%	No.	%
Yes	15	50.0	20	66.7
No	15	50.0	10	33.3
Total	**30**	**100.0**	**30**	**100.0**

Chi Square = 1.71

P value = 0.190

Table-6: Distribution of cases by presence of oligohydramnios
n = 60

Oligohydramnios	Group-A (Normal pregnant women) n = 30		Group-B (Pregnant women with risk factors) n = 30	
	No.	%	No.	%
Yes	09	30.0	15	50.0
No	21	70.0	15	50.0
Total	**30**	**100.0**	**30**	**100.0**

Chi Square = 2.50
P value = 0.113

Table-7: Distribution of cases by presence of polyhydramnios
n = 60

Polyhydramnios	Group-A (Normal pregnant women) n = 30		Group-B (Pregnant women with risk factors) n = 30	
	No.	%	No.	%
Yes	01	03.3	03	10.0
No	29	96.7	27	90.0
Total	**30**	**100.0**	**30**	**100.0**

Chi Square = 1.07
P value = 0.300

Table-8: Distribution of cases by amniotic fluid index
n = 60

Amniotic fluid index	Group-A (Normal pregnant women) n = 30		Group-B (Pregnant women with risk factors) n = 30	
	No.	%	No.	%
Increased	01	03.3	02	06.7
Decreased	10	33.3	16	53.3
Normal	19	63.3	12	40.0
Total	**30**	**100.0**	**30**	**100.0**

Chi Square = 3.30
P value = 0.192

Table-9: Distribution of cases by cardiotocography
n = 60

Cardiotocography	Group-A (Normal pregnant women) n = 30		Group-B (Pregnant women with risk factors) n = 30	
	No.	%	No.	%
Reactive	17	56.7	09	30.0
Non-reactive	13	43.3	21	70.0
Total	**30**	**100.0**	**30**	**100.0**

Chi Square = 4.34
P value = 0.037

Table-10: Distribution of cases by mode of delivery
n = 60

Mode of delivery	Group-A (Normal pregnant women) n = 30		Group-B (Pregnant women with risk factors) n = 30	
	No.	%	No.	%
SVD	15	50.0	07	23.3
Caesarean section	13	43.3	22	73.3
Forceps	02	06.7	01	03.3
Total	**30**	**100.0**	**30**	**100.0**

Chi Square = 5.557
P value = 0.062

Table-11: Distribution of cases by presence of meconium staining
n = 60

Meconium staining Sex	Group-A (Normal pregnant women) n = 30		Group-B (Pregnant women with risk factors) n = 30	
	No.	%	No.	%
Yes	02	06.7	10	33.3
No	28	93.3	20	66.7
Total	**30**	**100.0**	**30**	**100.0**

Chi Square = 6.667
P value = 0.010

Table-12: Mean values of different investigations in both groups
n = 60

Variables	Group-A (Normal pregnant women) n = 30	Group-B (Pregnant women with risk factors) n = 30	P value
	Mean±SD	Mean±SD	
Blood urea	28.03±4.98	31.10±5.10	0.022*
Serum creatinine	0.697±0.14	0.770±0.20	0.114
Serum uric acid	3.50±0.64	4.98±1.18	< 0.001*
S. billirubin	0.707±0.20	0.673±0.15	0.487
SGOT	29.67±6.85	38.33±16.38	0.010*
SGPT	28.63±8.49	40.33±21.29	0.007*
Total protein 24 hr protein (mg)	223.60±32.96	343.66±72.80	< 0.001*
Blood sugar fasting	76.77±8.39	87.07±16.81	0.004*
Blood sugar random	136.03±8.88	146.77±27.97	0.050*
SD ratio	2.40±0.39	3.63±1.11	< 0.001*

*Significant difference ($P \leq 0.05$)

Table-13: Distribution of cases by S/D ratio of umbilical artery
n = 60

S/D ratio	Group-A (Normal pregnant women) n = 30		Group-B (Pregnant women with risk factors) n = 30	
	No.	%	No.	%
≤ 3	27	90.0	06	20.0
> 3	03	10.0	24	80.0
Total	**30**	**100.0**	**30**	**100.0**

Chi Square = 6.667
P value = 0.010

Table 14 a: Mode of Delivery in Relation to S/D In (low risk group)
N=30

Parameters	S/D ratio ≤ 3 (n=27)		S/D ratio > 3 (n=3)		P value
	No.	%	No.	%	
Spontaneous vaginal delivery	20	74	1	33	0.035
Emergency caesarean section due to fetal distress	4	15	2	66	0.025
Forceps delivery	3	11	0	0	0.676

Table-14 b: Mode of delivery in relation to S/D ratio in (high risk group)
n = 30

Parameters	S/D ratio ≤ 3 (n=6)		S/D ratio > 3 (n=24)		P value
	No.	%	No.	%	
Spontaneous vaginal delivery	3	50	2	8.33	0.035
Emergency caesarean section due to fetal distress	2	33.33	20	83.33	0.025
Forceps delivery	1	16.66	2	8.33	0.676

Table 15 a: Neonatal outcome in relation to S/D ratio (low risk group)
N=30

Parameters	S/D ratio ≤ 3 (n=27)		S/D ratio > 3 (n=3)		P value
	No.	%	No.	%	
Apgar score >7 at 1 minute after birth	17	62	0	-	0.0001
Apgar score ≤ 5 at 5 minute after birth	1	3.70	1	33.33	< 0.001
Need for resuscitation	8	29.62	1	33.33	< 0.001
Admission to neonatal unit	1	3.70	1	33.33	< 0.001

Table-15 b: Neonatal outcome in relation to S/D ratio (high risk group) n=30

Parameters	S/D ratio ≤ 3 (n=6)		S/D ratio > 3 (n=24)		P value
	No.	%	No.	%	
Apgar score >7 at 1 minute after birth	3	50	3	12.5	0.0001
Apgar score ≤ 5 at 5 minute after birth	1	16.66	8	33.33	< 0.001
Need for resuscitation	1	16.66	8	33.3	< 0.001
Admission to neonatal unit	1	16.6	5	20.28	< 0.001

DISCUSSION

Doppler ultrasound velocimetry (a non-invasive method of measuring changes in blood flow velocity to study human pregnancy) was first reported in 1977 by Fitzgerald and Drumm, who used continuous wave Doppler to obtain flow velocity wave forms from umbilical vessels [8]. Since then it has become an integral part of fetal surveillance.

Umbilical artery is the most studied vessel in fetal circulation. Normally during pregnancy systolic:diastolic (S/D) ratio of umbilical artery (UA) falls with increasing gestation indicating progressive reduction in peripheral resistance. Pathology which reflects changes in placental villous resistance, impaired diastolic flow suggest that fetus is usually hypoxic and often academic. Many studies have shown that fetuses with abnormal umbilical flow waveform has increased incidence of fetal distress [9].

In this study, 60 patients were divided into two groups. Group-A included thirty pregnant women with low risk pregnancies. Group-B consisted of thirty pregnant women with high risk factors such as pregnancy with hypertension/preeclampsia, pregnancy with diabetes, pregnancy with intrauterine growth restriction (IUD) and twin pregnancies. A cut off value of S/D ratio of umbilical artery was taken ≤ 3 after 30 weeks of gestation till term.

This study shows that a fetus with raised,>3 S/D ratio of umbilical artery has higher rate of Perinatal asphyxia in term of low Apgar score, increased needs for resuscitation and admission to neonatal unit; And timely intervention in the form of decision for delivery reduced the incidence of perinatal morbidity and mortality. It also indicates that an abnormal flow waveform in umbilical artery reflects a high risk state i.e. fetal distress, require close fetal monitoring and appropriate decision about time and mode of delivery improves perinatal morbidity and mortality.

Ott (2000) reported in his study that presence of abnormal umbilical Doppler studies correlated better with caesarean section for fetal distress and neonatal intensive care admission [10]. These findings are consistent with present study.

Merchant et al indicated that impaired diastolic flows suggest that fetus is usually hypoxic [11]. The result is consistent with present study observation that an abnormal S/D ratio of umbilical artery shows compromised neonatal outcome indicating fetal distress.

Trudinger et al [12]have also shown that fetuses with abnormal umbilical FVW has increased incidence of fetal distress which support the findings of this study.

Gagnon and Van den Hof [13] support the use of umbilical artery Doppler studies in high risk pregnancies complicated with maternal hypertension, intrauterine growth restriction or multiple gestation. It did not support the use of umbilical artery Doppler as a screening tool in low risk pregnancies. These suggestions are consistent with results of this study.

Dubinsky et al [14] found that Doppler waveform abnormalities particularly systolic, diastolic S/D ratio greater than 4.0 are more sensitive predictor of poor neonatal outcome. Similar findings are observed in current study, but the cut off value of S/D ratio was greater than 3 in this study.

Bracero et al found that umbilical artery Doppler velocimetry improves the predictive value for adverse perinatal outcome in pregnancies complicated by diabetes [15] This finding is close tocurrent study results.

Sezik et al in a study found that abnormal umbilical artery Doppler studies in pregnancies complicated with pre-eclampsia/HELLP syndrome is related with bad perinatal outcome [16]. Similar findings were noted in this study.

Davies claimed that umbilical artery Doppler velocimetry is not an appropriate screening tool for low risk pregnancies but it plays a role in high risk pregnancy management especially in fetus identifies as being small for gestational age or pregnancies complicated by hypertension [17]. Similar conclusions were drawn from results of this study.

CONCLUSION

Umbilical artery Doppler studies is an integral parameter while evaluating health of high risk pregnancies especially preeclampsia, pregnancy with hypertension, growth restricted fetuses, diabetes mellitus, multiple gestation. It is apparent that abnormalities in umbilical artery flow velocity waveform encourage close fetal surveillance with other well established fetal testing modalities as fetal compromises seems to be very likely in this scenario. However, it is not appropriate as a screening tool for low risk pregnancies.

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