International Journal of Science and Research (IJSR)
ISSN (Online): 2319-7064
Index Copernicus Value (2013): 6.14 | Impact Factor (2013): 4.438

Assessment of Umbilical Artery Doppler Velocities: Which High Risk Conditions Will Benefit the Most?

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Abstract: ***Doppler Ultrasonography (USS) is a non-invasive imaging modality widely used for antenatal assessment in Obstetrics with an established safety record. Its' main use is to determine the flow velocities in the target vessels of a patient. In obstetrics, the technique is commonly utilized to assess the utero-placental and feto-placental transfusion via estimation of blood flow through the uterine and umbilical arteries. Various studies have established the value of umbilical artery Doppler velocities in improving obstetric outcomes via early identification of complications, improved obstetric decision making, minimizing neonatal deaths and avoidance of unnecessary cesarean sections, especially in pregnancies complicated with pre-eclampsia and IUGR. However, likely due to the overhead costs in equipment and training required to allow widespread use of Doppler ultrasonography, only a few studies regarding its use in South Asian populations are available. Further, the unnecessary and excessive use of such tests can contribute to wastage of resources as well as create unnecessary anxiety for pregnant mothers. Therefore, it is pertinent that clear information is available regarding which conditions will benefit most from Doppler studies of the umbilical artery flow velocities. Our study was designed to determine the value of Doppler ultrasonography in several conditions considered as high risk in pregnancy. It is hoped that this study will aid in developing guidelines for optimal use of Doppler ultrasonography in the resource poor setting. Objectives: To determine the efficacy of umbilical artery Doppler in managing high risk patients in tertiary care maternal referral center in Colombo, Sri Lanka, a lower-middle income country. Methodology: A prospective analytical study was carried out from 1st February 2009 to 31st July 2011 with the inclusion of pregnant mothers presenting to the De Soyza Maternity Hospital (a tertiary care hospital specializing in Obstetrics in Colombo, Sri Lanka) with at least one of - fundus less/more than dates, Amniotic Fluid Index (AFI) <6 &>16, Pregnancy Induced Hypertension (PIH), Established Intra-uterine Growth Retardation (IUGR), Chronic medical disorders, Gestational diabetes mellitus or Pre-gestational diabetes mellitus. Those with structural, genetic or chromosomal fetal anomaly, multiple pregnancy, pregnancy complicated with malnutrition or debilitating illness and mothers on oral steroids were excluded from the study. An interviewer administered questionnaire was used for the data collection after the study was explained to each participant and informed written consent obtained. It contained a detailed history and examination as well as most recent blood glucose levels the time of Doppler recording. Comprehensive fetal Doppler measurements were carried out and recorded in accordance with International Society of Ultrasound in Obstetrics and Gynaecology (ISUOG) standards. PI was set at <1.4 and RI at <0.7. Glycemic control was set at 90mg/dl pre-prandial and 130mg/dl post-prandial with target HbA_1C <6.2%. Blood pressure cut offs were set at 130mmhg systolic and 90mmhg diastolic. Proteinuria was defined as excretion of ≥ 300mg of protein in a 24h urine collection or ≥ +1 in urine heat coagulation in the absence of a UTI. Data were analyzed using the Statistical Package for Social Sciences (SPSS) 16. The p value was set at ≤ 0.05. Results: There were 8790 admissions during the study period and the Doppler rate was 5.18%. Four-hundred and fifty five pregnant mothers, a little less than half of them (n=185, 40.7%) primi gravida, were included in the study with a mean age of 29.13 ± 5.54 years (range 18 – 40 years). Mean period of amennorhoea at the time of the scanning was 34 weeks + 3 days. Seventy abnormal Doppler recording were observed and significant associations between pregnancy induced hypertension, abnormal CTG recording and low birth weight was observed. The association between abnormal umbilical artery Doppler velocities and gestational diabetes mellitus (GDM)/impaired glucose tolerances (IGT) and heart disease in pregnancy was less clear. Conclusions and recommendations: Umbilical artery Doppler has a proven value in managing high risk pregnancies especially PIH and IUGR. However, the Umbilical Artery Doppler indices have a limited value in impaired glucose tolerance/GDM and heart disease complicating pregnancy. The association between abnormal umbilical artery Doppler flow velocities and heart disease in pregnancy as well as GDM/IGT/PGDM was less clear and needs further evaluation.***

Keywords: Umbilical artery Doppler velocities, intrauterine growth retardation, pregnancy induced hypertension**,** high risk pregnancy

1. Introduction

Doppler ultrasound (USS) is a non-invasive imaging modality widely used in the field of Obstetrics and Gynaecology. In addition to being non-invasive, it has an added advantage of non-utilization of ionizing radiation [1] which makes it comparably safer than other imaging techniques. Since the invention by Dr. Ian Donalds in 1960, ultrasound has been in use for over 50 years. Up-to date, evidence suggests that USS in general poses no threat to either the fetus or the mother, although some studies advice caution in using color, Doppler and pulsed US within the first trimester [2][3].

Doppler imaging is used to assess blood flow through target blood vessels [4]. In antenatal care of a pregnant mother, Doppler scanning is often used to measure the blood flow in the uterine artery and then in umbilical arteries as a measure of utero-placental and feto-placental perfusion. Blood flow through the umbilical artery represents the level of placental vascular resistance which has a strong correlation with intrauterine growth retardation and multisystem effects of placental deficiency [5] including subsequent neural development.

Multiple studies around the world have firmly established the value of Umbilical artery Doppler as part of the comprehensive antenatal assessment of an at risk mother [5]. Its' use for antenatal assessment has been shown to improve

obstetric decision making [6] and obstetric outcomes by minimizing, caesarean delivery and fetal [7] and perinatal deaths[8], especially in those suspected or diagnosed with pre-eclampsia and intrauterine growth retardation [9]. Hence assessment of uterine artery up to first 24 weeks and assessment of umbilical artery flow velocities are useful as early predictors of vascular insufficiency

It is interesting to note that only a few studies regarding the use of Doppler ultrasonography in obstetrics has been carried out for the South Asian population, in this regard. The correct assessment of the Doppler requires good technology and training. Hence the use of Doppler on a routine basis cannot be afforded by developing countries. Further, it may add to unnecessary anxiety, operative delivery and legal issues if use on a routine basis. This study was designed to determine the value of the use of Doppler ultrasonography in managing high risk patients as well as the specific disorders for which it is of the greatest value. It is hope that this and similar studies will help develop guidelines for the optimal use of Doppler ultrasonography in the resource poor setting.

2. Objectives

Determine the efficacy of umbilical artery Doppler in managing high risk patients in tertiary care maternal referral center in Colombo, Sri Lanka, a lower-middle income country. (The Professorial Unit of De Soyza Maternity hospital of Colombo)

3. Methodology

3.1 Study design

A prospective analytical study

3.2 Inclusions

Pregnant mother who belonged to the following high risk categories presenting to the De Soyza Maternity Hospital during the study period were included in the study.

- Fundus less/more than dates
- Amniotic Fluid Index (AFI) <6 &>16
- Pregnancy Induced Hypertension (PIH)
- Established Intra-uterine Growth Retardation (IUGR)
- Chronic medical disorders
- Gestational diabetes mellitus based on abnormal Oral Glucose Tolerance Test (OGTT) 2h value of 140mg/dL,
- Pre-gestational diabetes mellitus – Post Prandial Blood Sugar (PPBS) >140mg/dL.

3.3 Exclusions

Pregnant mothers belonging to the following categories were excluded from the study.

- Structural genetic and chromosomal foetal abnormalities
- Multiple pregnancy
- Malnutrition and debilitating illnesses
- Mothers who were on oral steroids

3.4 Study duration

1st February 2009 to 31st July 2011.

3.5 Study Instruments:

An interviewer administered questionnaire including detailed history, examination, checking glycemic assessment and comprehensive fetal Doppler according to International Society of Ultrasound in Obstetrics and Gynaecology (ISUOG) standards was used as the study instrument. Accordingly, pulsatility index (PI) (< 1.4) and resistance index (RI) (<0.7). We also noted absent and reverse end diastolic flow in pictorial presentation at the pulse wave Doppler assessment aided by color magnification of the umbilical, middle cerebral and ductus venosus flows. Glycemic control was set at 90mg/dl pre-prandial and130mg/dl post prandial while target HbA1C was set at below 6.2% and the blood pressure was set at 130mmhg systolic and 90mmhg diastolic after 20 weeks of gestation in a previously normotensive patient. Proteinuria was defined as presence of ≥ 300mg of protein in a 24 hour urinary collection in the absence of a urinary tract infection (UTI). This value was equally represented with +1 of protein in a clean specimen after heat coagulation.

3.6 Data Collection

The purpose of the study was explained to the pregnant women and informed written consent was taken.

3.6 Analysis

Data was analyzed with statistical package for social sciences (SPSS) 16 and the significance was set as $p \leq 0.05$. Number of abnormal Doppler velocities vs normal were compared for each disorder in the study.

4. Results

455 pregnant women were enrolled in the study. Our Doppler rate was 5.18% (out of 8790 admissions). Subjects had a mean age of 29.13 ± 5.54 years (range 18 – 40 years). 185 (40.7%) were primi gravida. Mean period of amennorhoea at the time of Doppler scan was 34 weeks and 3 days.

There were 70 abnormal Doppler recordings. Statistically significant associations were observed between abnormal Doppler values and; presence of pregnancy induced hypertension (PIH) (p=0.027), Intra uterine growth restriction (IUGR) (p=0.006), abnormal cardiotocogram (CTG) recording (p=0.002), birth of a low birth weight baby (p=0.035). The associations between an abnormal Doppler recording and presence of gestational diabetes (GDM) /impaired glucose tolerance (IGT) (p=0.32) or heart disease (p=0.27) were not statistically significant. Of the 70 patients who had abnormal Doppler values 63 underwent emergency caesarean section. There was 4 still births and 14 early neonatal deaths due to low birth weights complicated with prematurity.

5. Conclusions and Recommendations

Umbilical artery Doppler has a proven value in managing high risk pregnancies especially PIH and IUGR. However, the Umbilical Artery Doppler indices have a limited value in impaired glucose tolerance/GDM and heart disease complicating pregnancy. Therefore the latter group will experience less benefit from the routine assessment of umbilical artery Doppler velocities.

6. Discussion

Sri Lanka has a strong, state sponsored healthcare system supported by an extensive network of public health units and hospitals spread across the island [10]. Healthcare services are provided free of charge at the point of delivery and has helped maintain country's public health indices at the highest level in South Asian region [11]. In 2010 Sri Lanka's maternal mortality rate of 35 per 100000 live births was ranked 67th out of 184 countries [12]. By 2013 this had further reduced to 29 maternal deaths per 100000 live births with 99% of the births being attended by skilled healthcare providers [13]. The quality of postgraduate and consultant medical care as well as the close nursing and mid midwifery care provided to the pregnant mothers can be seen as strong contributors for these achievements. To further improve these indices, appropriate utilization of modern technologies and validating them for the use in the local population is of increasing importance.

Our findings indicate that abnormal Umbilical artery Doppler indices during the antenatal period, strongly correlate with pregnancy induced hypertension, abnormal CTG recordings and low birth weight of the fetus. Similar correlations have been observed in multiple such studies worldwide. Harrington et al in their study of Umbilical artery Doppler indices found that abnormal Doppler velocities were significantly associated with subsequent development of PIH and delivery of a small for gestational age (SGA) baby as well as premature delivery. He hypothesized that abnormal Doppler findings indicate the failure of adaption of the maternal circulation which then result in poor neonatal outcomes [14]. Hanretty et al in their 2005 study involving 543 unselected pregnant women who underwent Umbilical artery Doppler assessment either between 26 to 30 weeks or 34 to 36 weeks or both, found that abnormal umbilical artery waveforms recorded at either gestation was associated with significantly low birth weights [15]. Herman et al in their paper on "Comprehensive Assessment of Fetal wellbeing" state that the umbilical artery Doppler recording reflect the downstream placental vascular resistance and hence correlate strongly with intrauterine growth restriction and multi-systemic effects of placental deficiency [5]. In addition, Borges et al in their study on the relationship between umbilical artery resistance index (UARI) and the placental thickness and birth weight in mothers with PIH found that the magnitude of abnormality was closely linked with lower placental thicknesses, AFIs and birth weights [16]. We suggest that future studies be designed to collect further evidence on such relationships.

In our study we found no significant association between maternal heart disease and the umbilical artery Doppler velocities. However it is believed that cyanotic heart disease could be an underlying cause for IUGR. In this study group, we have not had any mothers with cyanotic heart disease and in our study we have not had any significant Doppler changes in the patients with heart disease complicating pregnancy. This study illustrates that heart disease status has a less effect on abnormal umbilical artery Doppler, hence reducing the burden of monitoring for hypoxia of the fetus.

Our findings regarding GDM/IGT, is well in accordance with findings of similar studies worldwide. In our study, no significant association was seen among the diabetics in the study group. Although it is theoretical to believe pre-existing diabetes with vasculopathy could impede utero-placental and feto–placental circulation causing low birth weight babies. Even though we experience a few low birth weight babies in the pre-existing diabetic category we had not found any significant Doppler abnormality. In a study on Doppler umbilical artery flow velocity waveforms (FVW) in diabetic pregnancy, Frank et al, found that uncomplicated diabetic pregnancies had umbilical artery FVW similar to those in non-diabetic range. They also found no correlation between glycemic control in diabetic mothers and their umbilical artery FVWs [17].

In consideration of the above findings, we believe that it is justifiable to carry out routine umbilical artery Doppler assessments in pregnancies suspected to be complicated with pregnancy induced hypertension or intrauterine growth restriction due to variety of causes. Such assessment amounts to cost effective utilization of resources leading to improved pregnancy outcomes for both the mother and the fetus/neonate.

Recent evidence suggests that careful measurement of umbilical and uterine artery Doppler velocities can not only help early identification of complication, but offer clues to the severity of them. More in depth studies are required to validate such findings as well as further assess the value of Doppler studies in gestational diabetes mellitus and heart disease in preganancy.

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