Doppler Ultrasound assessment of the fetal Umbilical and Middle-cerebral Arteries in Intrauterine Growth Restriction (IUGR) in the Third trimester

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Abstract: The purpose of this study was to use Doppler indices to measure umbilical (UA) and middle cerebral (MCA) arteries for high risk pregnancy in 3rd trimester. Peak systolic velocity (PSV), end diastolic velocity (EDV), resistive index (RI) and pulsatility index (PI) for each artery were measured in 100 known cases of IUGR and compared with control group of 50 normal pregnant women. The mean (UA) indices were (PI 1.299, RI 0.749, S/D 5.137) and the mean indices for (MCA) were (PI 1.347, RI 0.732, S/D 3.833). The end diastolic flow (EDF) in (UA) was decreased in 39.3% cases, absent in 17.6%, positive in 37.2% and reversed in 5.9% cases but the (EDF) in (MCA) was increased in 75% and positive in 25%.The study showed (37.3%) of cases have oligohydrominus, (15%) decreased liquor, (3.9%) polyhyrominus and (43.11%) were normal.. The study suggested that (RI) of (UA) was a good predictive tool for detection of IUGR.

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1. Introduction:

Intrauterine Growth Restriction (IUGR) or fetal growth restriction is defined as less than 10% of predicted fetal weight for gestational age (Alan, 2003). It is a serious condition in which the fetus is not growing adequately and is smaller than expected for its dates. IUGR is present in almost half of all stillbirths. Surviving infants with severe IUGR are at risk for long-term developmental delay, neuromotor disabilities such as cerebral palsy and neurobehavioral disorders including impaired school performance, social skills, and fine motor control. Epidemiologic studies have linked IUGR with significant metabolic conditions (obesity, type 2 diabetes mellitus) and cardiovascular disorders (ischemic heart disease, hypertension). (Alan, 2003).

There are two major categories of IUGR: symmetrical and asymmetrical. Some conditions are associated with both symmetrical and asymmetrical growth restriction.

In Asymmetrical IUGR there is restriction of weight followed by length and it is found to be more common than symmetrical IUGR. Symmetric IUGR is commonly known as global growth restriction and indicates that the fetus was developed slowly throughout the duration of pregnancy. (White, 2016).

IUGR has many possible causes which can divided into maternal, uteroplacental and fetal. The common cause which related to maternal are anemia, pulmonary disease, alcoholic, smoking, cardiovascular and renal diseases, hypotension and diabetes mellitus. The uteroplacental causes are placental insufficiency, uterine malformation and preeclampsia. The fetal causes are chromosomal abnormalities and infection. (Hobbins, 2006).

Delayed growth puts the Fetus at risk of certain health problems during pregnancy, in delivery, and after birth. They include low birth weight, decreased oxygen levels, low resistance of infection, low Apgar scores, and other complications. (Vandenbosche and Kirchner, 1998)

Previously, invasive techniques such as amniocentesis or direct fetal blood sampling had to be performed every few weeks in pregnancies with IUGR for severe fetal anemia that could result in death. In the late 1990s, maternal-fetal medicine specialists found that Doppler ultrasonography could accurately diagnose moderate to severe fetal anemia by measuring blood flow in the baby's brain. This novel and noninvasive approach has revolutionized monitoring of pregnancies with IUGR and has made invasive fetal testing for this indication generally unnecessary (Chudleigh, 2004). Angle-independent indices differ among the different cerebral arteries. The middle cerebral artery is the most studied cerebral artery because it is easy to sample; in addition it provides information on the cerebral blood flow in normal and IUGR fetuses; and it can be sampled at an angle of 0° between the ultrasound beam and the direction of the blood flow. Therefore, for the middle

cerebral artery we are able to determine angle-independent indices and also the real velocity of blood flow. in normal fetuses the MCA have a high PI and decreased EDF, In IUGR fetuses there is an increase in MCA diastolic flow velocities, and a corresponding decrease in MCA PI reflecting to the redistribution of the blood flow from the fetal periphery to the brain; this phenomenon is called the "brain-sparing effect in response to chronic hypoxemia. In this study we focus our measurements on fetal umbilical and middle-cerebral arteries because of their importance for detection of any abnormalities underlying IUGR.

2. Materials and Method:

2.1 Ultrasound system:

The ultrasound unit used was a General Electric (GE) medical system (logic 5 expert), with a convex probe (3.5MHz).

2.2 Subjects:

This study was conducted at different hospitals, clinics and diagnostic centers of medical ultrasound. The population of study was pregnant women referred to ultrasound clinic with high risk of intrauterine growth restriction diagnosed clinically. Sample selection and negligence depend on two criterions; the included subjects are pregnant women of high risk pregnancy suspected to have intrauterine growth restriction in the 3rd trimester; the excluded are gestational age less than 3rd trimester, congenital malformation and chromosomal abnormalities, twin's pregnancy and oligohydramnios caused by Early-rupture membrane (ERM).

Due to extended scope of our exclusion criteria the sample size was 100 pregnant women with IUGR at 3rd trimester, they were scanned and compared with control group of 50 normal pregnancies.

2.3 Techniques and Measurements:

The sample under study has been scanned to visualize the umbilical and middle cerebral arteries in comfortable position and a coupling medium (e.g., gel) is used. Pulsed wave ultrasound is used to provide data for Doppler sonograms and color flow images. A scanner with a mean frequency of 3.5 MHZ and color Doppler, transabdominal (TA) curve linear transducer was used. The angle of insonation was kept at 55 degree in all cases.

Several transducer positions were used in this research to examine the umbilical and middle cerebral arteries in long-axis (longitudinal) planes and short-axis (transverse), the planes was obtained from an anterior and lateral or posterolateral approach of the fetaus depending on which best shows the vessels.

The umbilical and middle cerebral arteries were studied by the presence of parallel line echoes, which displayed a pulsatile activity on real time image, the Power Doppler (PD) followed by Pulse Wave Doppler (PWD) modes were applied for the spectral analysis and determination the values of peak systolic velocity (PSV) in cm/sec, end diastolic velocity (EDV) in cm/sec, resistive index (RI) and pulsatility index (PI) for each artery respectively.

The obtained numerical values of the above different variable were taken from the middle part of each artery because flow pattern seem to be steady and uniform, which actually help to avoid any misleading or wrong values. The recordings were taken close to the fetal insertion in quite fetal manoveur. The flow velocity waveforms obtained from umbilical and MC arteries were computed automatically, the program identified individual cardiac cycles and computed peak systolic velocity. End diastolic velocity and S/D ratio.

3. Results:

The results are shown in the following Tables and Figures.

Table 3.1: the Descriptive Statistics of UA and MCA indices

	Mean		Std.
	Statistic	Std. Error	
PI (UA)	1.299	0.0633	0.4520
RI (UA)	0.749	0.0277	0.1976
S/D (UA)	5.137	1.0630	7.5911
PI (MCA)	1.347	0.0394	0.2813
RI (MCA)	0.723	0.0116	0.0825
S/D (MCA)	3.833	0.1481	1.0575
Fetal Weight	1.8656	0.0625	0.4468

Table 3.2: the Umbilical Artery EDF frequency and percentage

	Frequency	Percent
Absent	18	18
Decreased	37	37
Positive	39	39
Reversed	6	6

Table 3.3: the Middle Cerebral Artery EDF frequency and percentage

	Frequency	Percent
Increased	75	75
Positive	25	25

Table 3.4: the liquor volume in IUGR

	Frequency	Percent
Decreased	16	16
Oligo	37	37
Poly	4	4
Normal	43	43

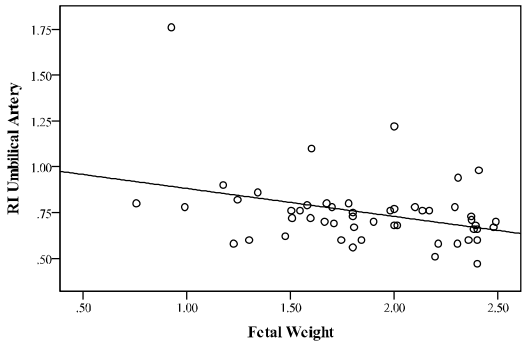

Figure 3.1: the relationship between fetal weight and RI of UA

Table 3.5: the IUGR Classification

	Frequency	Percent
Symmetric	77	77
Asymmetric	23	23

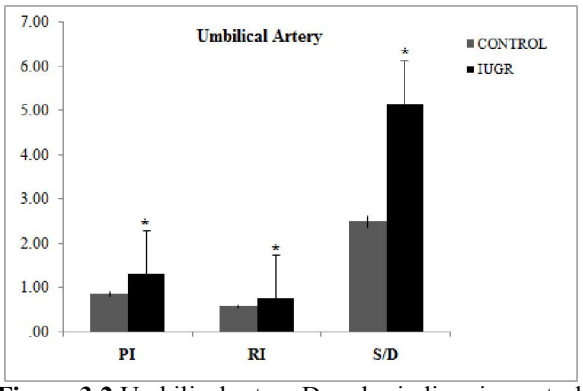

Figure 3.2 Umbilical artery Doppler indices in control group and IUGR, data presented as mean (a strike indicates the significant difference ($p < 0.001$)

Table 3.6: the EDF Umbilical Artery vs. Liquor Volume Crosstabulation

		Liquor Volume				Total
		Decreased	Oligo	Poly	Normal	
EDF (UA)	Absent	6	6	0	6	18
	Decreased	8	16	2	14	40
	Positive	2	11	2	21	36
	Reversed	0	4	0	2	6
Total		16	37	4	43	100

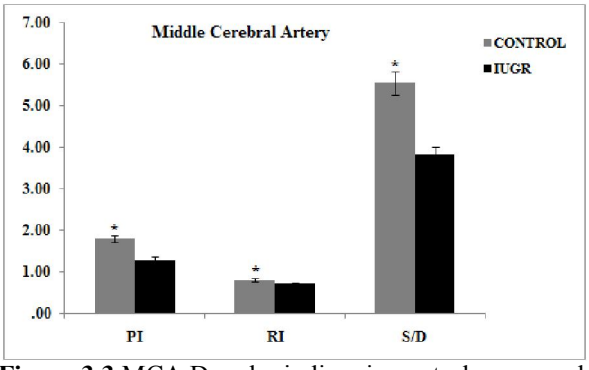

Figure 3.3 MCA Doppler indices in control group and IUGR, data presented as mean (a strike indicate the significant difference ($p < 0.001$)

4. Discussion:

The study has been carried out in Soba Hospital affiliated to University of Khartoum, with general aim to explore and record the Doppler Ultrasound assessment of the fetal umbilical and middle-cerebral arteries in Intrauterine Growth Restriction (IUGR) during third trimester.

The result of the study showed that the mean Umbilical artery (UA) indices (PI 1.299, RI 0.749, S/D 5.137), on the other hand, the mean middle cerebral artery (MCA) indices (PI 1.347, RI 0.723, S/D 3.833), all these findings found to be significantly higher compared with the control group in umbilical artery and lower in middle cerebral artery.

Furthermore the mean fetal weight was (1.866 kg). This result in line with Mehmet Ozeren et.al study, which stated that the mean of UA and MCA indices were higher in preeclamptic patients without IUGR than normal pregnancies, these prove that Doppler Indices had a good predictive value among severe intrauterine growth restriction than in the mild cases, because in severe cases the values of indices become more obviously higher (Ozeren et al., 1999).

Regarding the End diastolic flow (EDF) of Umbilical artery, the study revealed that decreased in EDF seen in 39.3% of cases, absent of EDF represents 17.6%, positive EDF (37.2%) and the reversed EDF was (5.9%). Decreased, absent or reversed EDF underlying in vascular stress in case of placental insufficiency in which a higher vascular resistance exist, as a results diastolic flow decreased. The absent

or reversed EDF depend on severity of placental insufficiency (Krishna and Bhalerao, 2011).

The end diastolic flow (EDF) of middle cerebral artery, it was increased in 75% of cases and positive in 25%. The cerebral resistance index values decrease as a rensult of cerebral vasodilatation, this phenomenon is called the brain sparing effect, increased blood flow in vital organs in case of growth restriction as a result of redistribution of blood flow.

The Liquor volume has been assessed, the study showed that (37%) of cases have an oligohydramnios, (15%) decreased liquor, (3%) polyhydramnios and (43%) within the normal range of liquor volume. In growth-restricted fetuses, chronic hypoxia results in shunting of fetal blood away from the kidneys to more vital organs (Luton et al., 2004).

The study showed that the majority of cases of IUGR were symmetrical IUGR (76%), and (23%) were asymmetrical IUGR; Asymmetric IUGR results from any cause of placental insufficiency affecting the delivery of oxygen and vital nutrients to the fetus, thus abdominal circumference affected. Symmetrical IUGR caused by fetal chromosome anomalies or infections, thus the sensitivity of the umbilical artery Doppler indices increases in asymmetrical growth retardation (Arias, 1994).

A significant negative relationship between RI of umbilical artery and fetal weight in IUGR cases was noticed ($p < 0.05$, $r = 0.35$). The fetal weight decreased when the Resistive Index of umbilical artery was increased (Borges et al., 2013).

Doppler velocimetry studies of placental and fetal circulation can provide important information regarding fetal well-being, yielding an opportunity to improve fetal outcome. Our results suggested that the RI of umbilical artery was a good predictive tool for neonatal outcome in postterm pregnant women and could be used to identify the fetus at risk of morbidity.

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