

## Doppler studies on the fetal renal artery and middle cerebral artery in the growth restricted fetus

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### Abstract

**Background:** A disease known as intrauterine growth restriction (IUGR) causes a fetus to be born prematurely tiny for its gestational age. Some complications might arise throughout pregnancy, labor & the newborn period if the baby isn't developing normally. **Aim & objectives:** The goal of the research was to analyze the connection among Doppler measures, birth weight, amniotic fluid index & fetal condition at delivery, as well as to look at alterations in the fetal renal artery with middle cerebral artery (MCA) by Doppler sonography in the growth limited fetus. **Subjects and methods:** One hundred pregnant women who came to our ultrasound facility at Benha University Hospital for a Doppler screening participated in this cross-sectional trial. **Results:** Birth weight had a positive correlation with renal artery PI (0.481), negatively correlated with Middle cerebral artery PI (-0.611) and additionally significantly associated with Renal artery V max (0.618). **Conclusion:** Reduced fetal renal blood flow was linked to intrauterine growth limitation. The results of this study provide credence to the idea that fetal growth restriction can lead to a higher possibility of developing renal illness & hypertension in retrospect.

**Keywords:** Ultra-sound assessment, Renal blood flow velocimetry, Fetal kidney volume, Intrauterine growth restriction.

### 1. Introduction

Iatrogenic prematurity is largely caused by IUGR, a very important prevalent pregnancy problem. Abnormal placentation, which is often linked to decreased placental blood flow, is the primary reason for intrauterine growth restriction [1].

Those pregnancies in which the fetus not grow to its full genetic potential are said to have intrauterine growth restriction. Normal placental function and fetal growth require sufficient blood flow from both the mother & the father. Fetal circulation undergoes compensatory modifications in response to disruptions in the fetoplacental circulation, which in turn results in placental deficiency [2].

SGA is not the same as fetal growth restriction (FGR). whereas fifty to seventy percent of SGA babies are fundamentally tiny, with fetal growth suitable for maternal size & ethnicity, not all fetuses/infants with growth restriction are SGA. Infants with severe SGA are more likely to develop FGR. The term "growth restriction" refers to a pathological reduction in normal fetal growth. Therefore, fetal compromise (abnormal Doppler investigations, decreased fluid volume) may be observed in cases of growth restriction. Low birth weight (LBW) babies are those that are born weighing under two and a half kilograms [3].

Malnutrition, particularly in mothers, is a leading cause of FGR. Fetal growth restriction can be caused by maternal illnesses, particularly chronic infections like tuberculosis

& malaria. Fetal growth restriction can be brought on by conditions such hypertension, diabetes mellitus, anemia, heart illness, chronic lung disease, apnea along with SL [4].

Doppler ultrasound is an inexpensive way of assessing the health of a pregnancy & its potential results. This method allows for the evaluation of fetoplacental health by examining placental & fetal arteries. Absolute velocities inside an artery can be measured with Doppler ultrasound to determine the resistance index (RI). In order to detect fetal compromise induced by an irregular uteroplacental or fetal circulation, Doppler has become standard practice in pregnant women [5].

Certain regions of the brain are more vulnerable to hypoxia injury due to unknown reasons while regional hemodynamic redistribution may be one of these mechanisms. Evidence from a small number of investigations in IUGR babies suggests that, during hypoxic intrauterine growth restriction, the human fetal brain may undergo hemodynamic internal changes, as measured by Doppler parameters in the fetal brain arteries [6].

The present research intended to determine whether there is a connection among amniotic fluid index, Doppler readings, birth weight as well fetal condition in a growth-restricted fetus, as well as whether or not these variables modify during pregnancy.

## 2. Patients and Methods

Pregnant women seeking a Doppler assessment at our ultrasound facility at Benha University Hospital participated in this cross-sectional trial. The investigation was carried out with the blessing of the Benha Faculty of Medicine's Local Ethics Committee on research involving human subjects. Everyone who took part gave their written authorization.

Epi-Info, a statistical package developed by the World Health Organization & the Centers for Disease Control & Prevention (CDC), Atlanta, USA, Georgia, version 2002, was used to determine the sample size and conduct the power analysis. The following factors were considered when developing the sample size: Instance size based on the aforementioned criteria was determined at N more than 81, but we raised it to 100 to compensate for missed information and improve the quality of data. The study is cross-sectional in design, has a 95% confidence limit as well as expects to detect an alteration of seventy percent with a ten percent margin of error.

Setting: Benha University's Department of Obstetrics & Gynecology, part of the Faculty of Medicine.

**Inclusion criteria:** One hundred pregnant women who were carrying a single child along with whose pregnancies had been accurately dated (either by a specific last menstrual period or by first-trimester ultrasound) and who voluntarily consented to participate in the study had their fetuses examined sonographically for renal artery as well as MCA indices at 26-35 weeks of gestation.

**Exclusion Criteria:** Individuals who decline to participate in the research, fetuses

with known chromosomal or severe structural abnormalities, people whose amniotic fluid is bloody or meconium-tinged, fetuses with structural malformations identified after delivery, and those carrying multiples are excluded from the study.

### Methods

All participants were subjected to

**Full history taking:** Including personal history, history of the present illness, family history, maternal age, drug history, Gestational age, maternal multiple disorders (e.g., diabetes mellitus, rheumatoid diseases, chronic hypertension, & substance abuse).

**Clinical examination:** including physical exam along with nutrition; pulse, height to weight profile, blood pressure, current weight; head also neck, pelvic area tenderness, breasts, abdomen, extremities as well as back, heart also lungs, neuromuscular; & pelvic evaluation - speculum and bimanual examination, clinic pelvimetry, uterine size, fetal heart rate, as well as cervical check among 36 as well 39 weeks. The cervix should be examined for dilatation, effacement, presentation in addition to station.

**Imaging:** middle cerebral artery, Serial Doppler measurements of the renal artery, also amniotic fluid index.

**Statistical Analysis:** Any information was gathered, tabulated & analyzed statistically using SPSS 26.0 for Windows (SPSS Inc., Chicago, IL, USA). Quantitative information was defined using range (min then max), standard deviation, median & mean. **The functioned tests were Pearson correlation coefficient:** utilized to quantify the strength of a connection is amongst 2 parameters.

## 3. Results

**Table (1)** Gestational age features of the population under examination

	Study population (n = 100)
<b>Gestational age (weeks)</b>	
<b>Mean ± SD.</b>	<b>30.58 ± 1.97</b>
<b>Median (IQR)</b>	<b>31 ( 29 - 32 )</b>
<b>Range (Min-Max)</b>	<b>10 ( 25 - 35 )</b>

$\chi^2$ : Chi- Square test

SD: standard deviation

**Table (1) showed Gestational age characteristics among the study population. Gestational age in the trial community extended from 25 to 35 with mean ± SD = 30.58 ± 1.97.**

**Table (2)** fetal condition at birth characteristics among the study population

	Study population (n = 100)
<b>Birth weight (g)</b>	

<b>Mean ± SD.</b>	<b>2055.76 ± 237.27</b>
<b>Median (IQR)</b>	<b>2063 ( 1893 - 2203 )</b>
<b>Range (Min-Max)</b>	<b>1148 ( 1582 - 2730 )</b>
<b>Apgar score at 1 min</b>	
<b>Mean ± SD.</b>	<b>6.83 ± 1.62</b>
<b>Median (IQR)</b>	<b>7 ( 6 - 8 )</b>
<b>Range (Min-Max)</b>	<b>7 ( 2 - 9 )</b>
<b>Apgar score at 5 min</b>	
<b>Mean ± SD.</b>	<b>8.98 ± 0.75</b>
<b>Median (IQR)</b>	<b>9 ( 8.75 - 9.25 )</b>
<b>Range (Min-Max)</b>	<b>3 ( 7 - 10 )</b>

Table (2) showed fetal condition at birth characteristics among the study population. In the population studied, the range of birth weights was 1582 to 2730 with mean ± SD = 2055.76 ± 237.27. Apgar score 1 min in the trial population extended from 2 to 9 with mean ± SD = 6.83 ± 1.62. Apgar score 5 min in the research subjects extended from 7 to 10 with mean ± SD = 8.98 ± 0.75.

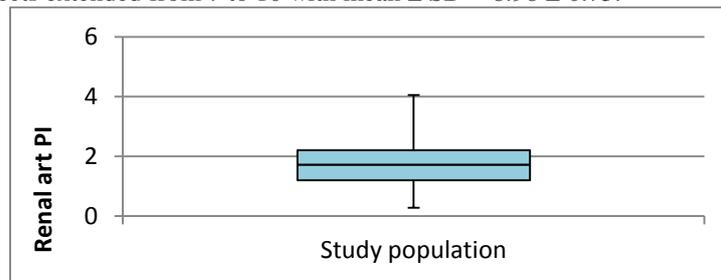


Fig. (1) Box-plot displaying survey population data pertaining to Renal art PI.

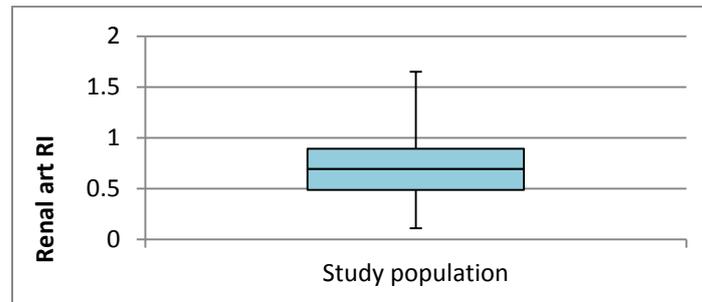


Fig. (2) Box-plot showing trial population data regarding Renal art RI

Table (5) Measurements of Middle cerebral artery pulsatility index amongst the trial population

	<b>Study population (n = 100)</b>
<b>Middle cerebral artery PI</b>	
<b>Mean ± SD.</b>	<b>0.75 ± 0.37</b>
<b>Median (IQR)</b>	<b>0.68 ( 0.48 - 1 )</b>
<b>Range (Min-Max)</b>	<b>1.92 ( 0.02 - 1.94 )</b>

Table (5) showed Measurements of Middle cerebral artery pulsatility index among the study population. Middle cerebral art PI in the research subjects ranged from 0.02 to 1.94 with mean ± SD = 0.75 ± 0.37.

Table (6) Measurements of Middle cerebral artery resistance index between the study population

	<b>Study population (n = 100)</b>
<b>Middle cerebral artery RI</b>	
<b>Mean ± SD.</b>	<b>0.3 ± 0.15</b>

<b>Median (IQR)</b>	<b>0.28 ( 0.2 - 0.41 )</b>
<b>Range (Min-Max)</b>	<b>0.78 ( 0.01 - 0.79 )</b>

Table (6) showed Measurements of Middle cerebral artery resistance index among the study population. Middle cerebral art RI of participants in the research were from 0.01 to 0.79 with mean  $\pm$  SD =  $0.3 \pm 0.15$ .

**Table (7)** Measurements of Renal artery peak systolic velocities among the study population

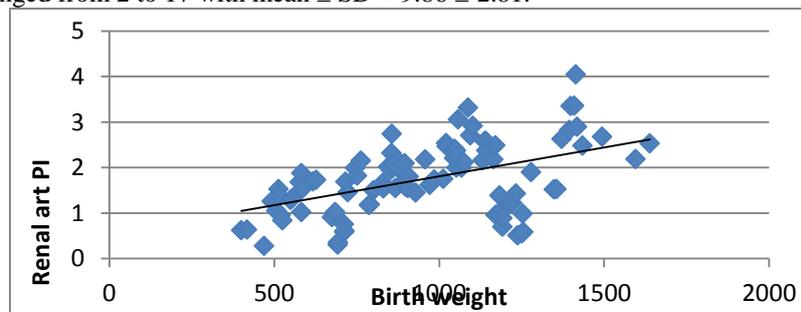
<b>Study population (n = 100)</b>	
<b>Renal artery V max (cm/sec)</b>	
<b>Mean <math>\pm</math> SD.</b>	<b>109.66 <math>\pm</math> 26.13</b>
<b>Median (IQR)</b>	<b>109 ( 92.75 - 129.25 )</b>
<b>Range (Min-Max)</b>	<b>129 ( 52 - 181 )</b>

Table (7) showed Measurements of Renal artery peak systolic velocities among the study population. Renal art V max in the study population ranged from 52 to 181 with mean  $\pm$  SD =  $109.66 \pm 26.13$ .

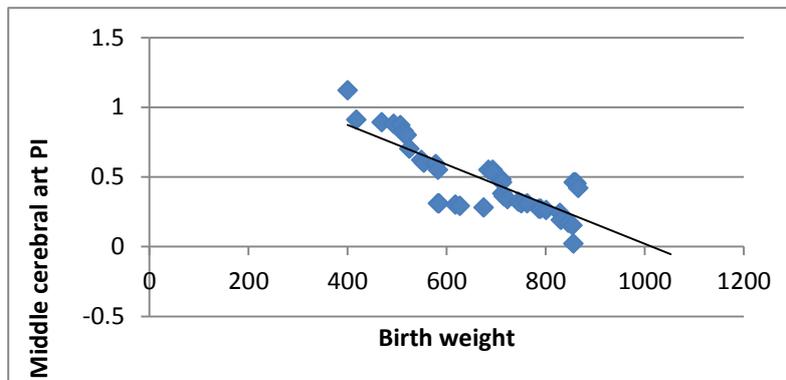
**Table (8)** Measurements of Amniotic fluid index amongst the trial population

<b>Study population (n = 100)</b>	
<b>AFI</b>	
<b>Mean <math>\pm</math> SD.</b>	<b>9.86 <math>\pm</math> 2.81</b>
<b>Median (IQR)</b>	<b>10 ( 8 - 12 )</b>
<b>Range (Min-Max)</b>	<b>15 ( 2 - 17 )</b>

Table (8) showed Measurements of Amniotic fluid index among the study population. AFI in the study population ranged from 2 to 17 with mean  $\pm$  SD =  $9.86 \pm 2.81$ .



**Fig. (11)** Scatter plot graph showing correlation between Birth weight and Renal artery PI.



**Fig. (12)** Scatter plot graph showing correlation between Birth weight and Middle cerebral artery PI.

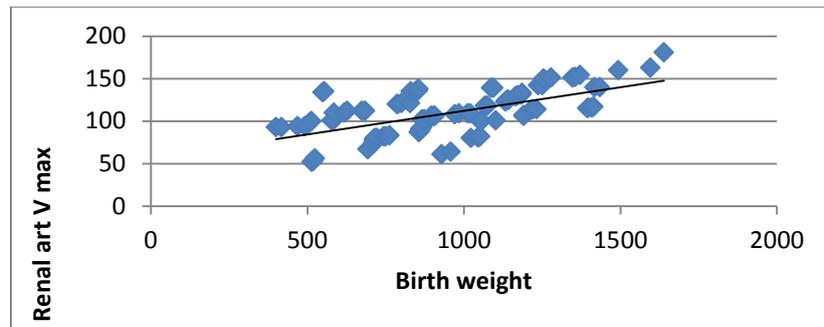


Fig. (13) Scatter plot graph showing correlation between Birth weight and Renal artery V max.

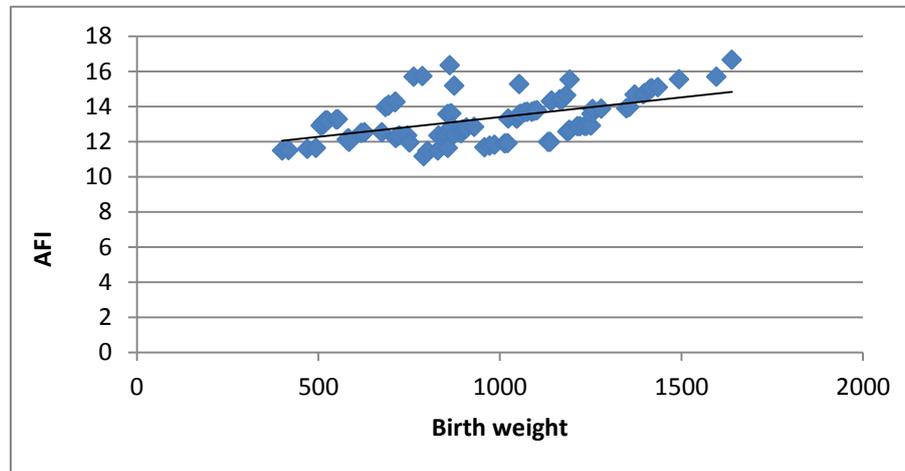


Fig. (14) Scatter plot graph illustrating correlation amongst Birth weight & Amniotic fluid index

#### 4. Discussion

Examination of the maternal, placental & fetal vascular patterns is crucial for early detection & prediction of intrauterine growth restriction [7].

In this study, we aimed to examine changes in the fetal renal artery and middle cerebral artery by Doppler sonography in the growth restricted fetus & to analyze how Doppler data correlates with additional factors including amniotic fluid index, birth weight even fetal health within delivery.

Analysis of our findings revealed that Gestational age of the participants in the research varied from 25 to 35 with mean  $\pm$  SD =  $30.58 \pm 1.97$ .

Comes in comparison with our results, the trial of [8] which intended at evaluating the relation among kidney volume as well as renal artery Doppler in intra-uterine growth restriction; performed on Group A: Pregnant women with restricted fetal growth as well Group B: women with regular pregnancy; stated that gestational age at randomization; group A was  $32.8 \pm 2.6$  &  $33.4 \pm 3.2$  in group B with an insignificant value.

[9] The mean gestational age by date was  $36.72 \pm 1.53$  weeks in the IUGR group in

addition  $37.74 \pm 1.41$  weeks in the normal group, with no variance amongst the 2 groups. However, the mean gestational age by ultrasound was  $32.5 \pm 2.02$  weeks in the IUGR group as well as  $36.74 \pm 1.40$  weeks in the typical group.

In the current study, Birth weight in the research population extended from 1582 to 2730 with mean  $\pm$  SD =  $2055.76 \pm 237.27$ . Apgar score 1 min in the trial subjects from 2 to 9 with mean  $\pm$  SD =  $6.83 \pm 1.62$ . Apgar score 5 min in the research population ranged from 7 to 10 with mean  $\pm$  SD =  $8.98 \pm 0.75$ .

Furthermore, [10] reported that small birth weight & low Apgar score were originate in 40.2 percent also 26.9 percent of all the newborn, respectively.

In the current study, we found that renal artery PI in the research population from 0.28 to 4.05 with mean  $\pm$  SD =  $1.75 \pm 0.76$ . Renal artery RI in the trial subjects from 0.11 to 1.65 with mean  $\pm$  SD =  $0.71 \pm 0.31$ .

In the study of [11], reported that the values of the renal artery pulsatility index (PI) for the individuals varied from (1.3) to (2.8), with PI values in the normal range for (5) of the total (25) cases (ranging from (1.3) to (1.6) & readings above the normal range for

(20) of the cases (ranging from (1.9) to (2.8) of the cases.

[12] indicated that an average UAD pulsatility index of 1.060.45, with a normal range of 0.47–2.5 with an abnormal range of 0–50%.

In the present study, Middle cerebral artery PI in the trial population extended from 0.02 to 1.94 with mean  $\pm$  SD =  $0.75 \pm 0.37$ . Middle cerebral art RI in the study population varied from 0.01 to 0.79 with mean  $\pm$  SD =  $0.3 \pm 0.15$ .

[12] reported that the mean MCD PI was  $1.33 \pm 0.38$  as it ranged from 0.71 to 2 and it was irregular in 52.5 percent of participants & normal in 47.5 percent of cases.

In the research on our hands, we found that Renal art V max in the trial population from 52 to 181 with mean  $\pm$  SD =  $109.66 \pm 26.13$ .

In the current study, AFI participants in the investigation had ages ranging 2 to 17 with mean  $\pm$  SD =  $9.86 \pm 2.81$ . Pearson's Correlation between Birth weight and Amniotic fluid index was 0.531.

In the study of [13], There were 14 individuals in the first group with a birth weight below 2.5 kg, compared to 38 patients in Group 2 with a birth weight below 2.5 kg; the distinction was statistically significant ( $p = 0.001$ ). [14] revealed that the existence of an AFI under 5 substantially enhanced the risk for an SGA child in simple term pregnancies with oligohydramnios. [15] infants with AFI less than 5 were more likely to be born LBW, suggesting a link between oligohydramnios & growth restriction.

In the current trial, we found Positive correlation between Birth weight and renal artery PI was 0.481, negative correlation between Birth weight & Middle cerebral artery PI was -0.611, and positive significant correlation between Birth weight and Renal artery V max was 0.618.

[16] observed a progressive decrease in peak systolic velocities (Vmax) in renal arteries and a strong association between Vmax and both pH levels in venous cord blood and /SDAFI during the course of study. These results indicate that the renal perfusion, urine production & amniotic fluid volume of the growth-restricted fetus are all lower than they would be if the fetus had a normal cardiac output or a normal proportion of cardiac output directed towards the kidneys. We identified a strong association among Doppler values in the ductus venosus as well as  $\Delta$ /SDAFI, which lends credence to this theory.

[17] reported on the correlation between aberrant velocity waveforms and the

forecasting of fetal growth limitation. Some babies born under the 10th percentile are just constitutionally little and healthy, whereas others may have been exposed to a pathogenic process during gestation. Doppler ultrasonography has been demonstrated through meta-analysis to significantly enhance perinatal outcome in high-risk pregnancies with intrauterine growth restriction.

In trial of [18], When comparing fetuses with and without intrauterine growth retardation, a significant distinction was observed in Doppler ultrasonography readings of the renal artery. Renal arterial blood flow velocities demonstrated lower systolic flow alongside a raised resistive index, in comparison to the usual picture.

[9] stated there was a substantial disparity among each of the groups in terms of umbilical artery Doppler along with fetal renal artery Doppler as the mean of resistive index of umbilical artery of IUGR cases was ( $0.87 \pm 0.01$ ) & for control group was ( $0.59 \pm 0.01$ ) in addition the mean of umbilical artery pulsatile index in intrauterine growth restriction individuals was ( $1.74 \pm 0.14$ ) while that of the control group was ( $0.80 \pm 0.144$ ). In study of [9] We noticed a statistically important distinction amongst the two groups with in terms of renal volume, discovering that the IUGR persons had lower renal volume than the normal group. Right renal volume was significantly lower in the IUGR group ( $10.35 \pm 0.58$  vs.  $15.44 \pm 1.76$ ,  $p$  less than 0.05) compared to the control group.

Additionally, [19] The Doppler indices of the umbilical artery along with the middle cerebral artery (PSV, PI, RI) were found to have a highly significant connection with newborn outcome in the intrauterine growth restriction group. High specificity and sensitivity of A wave RI, PI in IUGR group on Ductus venosus Doppler was also associated with positive neonatal outcomes.

## 5. Conclusion

Fetal renal blood flow appears to be reduced in individuals with intrauterine growth restriction. Outcomes from the present investigation provided credence to the idea that intrauterine growth restriction might contribute to renal disease & hypertension later in life. Infants whose Doppler scans were abnormal tended to be smaller at birth than their healthy counterparts. Doppler indices of the middle cerebral artery as well as the renal artery were thus more predictive of fetal fate in intrauterine growth restriction than the umbilical artery. This research gives more evidence that renal volume can be utilized as a measure for the

diagnosis of IUGR and additionally that intrauterine growth restriction may be associated to renal illness & hypertension in later life.

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