Doppler Study of the Fetal Renal Artery in Oligohydramnios with Post-term Pregnancy

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Abstract

Background: Pregnancies that extend beyond due date (post-term) are associated with an increased risk of complications for both the mother and fetus, including morbidity and mortality. Doppler ultrasound offers a non-invasive way to assess blood flow patterns in the fetal renal artery, but the current evidence regarding the link between altered renal flow and oligohydramnios (low amniotic fluid volume) remains inconclusive.

Objectives: To assess the correlation between fetal renal artery Doppler measurements and amniotic fluid volume indices.

Patients and methods: In a study of 68 post-term pregnant women, two groups were formed. The first group had oligohydramnios (AFI < 5 cm), while the second group had normal amniotic fluid capacity (AFI > 5-25 cm). Researchers conducted a thorough history, sonographic evaluation, clinical examination, and standard laboratory tests. Doppler examination assessed fetal renal artery characteristics, including blood flow (FRABF), resistance index (RI), pulsatility index (PI), acceleration time (AT), and systolic/diastolic ratio (S/D).

Results: A significant positive correlation between AFI and FRABF were identified in our investigation. On the other hand, AFI exhibited substantial negative correlations with the doppler of renal artery indices: RI, PI, PS, and AT (correlation coefficients r=-0.549, r=-0.330, r=-0.258, and r=-0.478, respectively; all p-values<0.05). Furthermore, the Doppler indices of the study and control groups demonstrated significant differences statistically (all p-values<0.05).

Conclusions: Doppler ultrasonography reveals a link between oligohydramnios and renal artery flow waveforms. Changes in RI, PI, AT, and FRABF values can serve as rapid delivery indicators in post-term pregnancies with reduced amniotic fluid volume.

Keywords: Doppler Study; Oligohydramnios; Foetal Renal Artery; Post-term Pregnancy.
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Introduction

The World Health Organization identifies the pregnancy of post-term as a pregnancy exceeding 42 weeks + 0 days. Approximately 5 to 10 percent of all pregnancies persist for a minimum of 42 weeks pregnancy **(Bruinsma et al., 2022)**.

Despite the fact that the absolute mortality risk has been reduced by advancements in obstetrics and newborn care, retrospective investigations of these so-called post-term pregnancies have demonstrated an increased risk to the foetus and mother. The incidence of perinatal mortality, which encompasses neonatal fatalities and stillbirths, is 2-3 deaths per thousand deliveries at forty weeks' gestation. By 42 weeks, this rate has nearly doubled and is 4 to 6 times greater at 44 weeks **(Muglu et al., 2019)**.

Oligohydramnios is defined by the volume of amniotic fluid less than the anticipated value for the age of gestation. Oligohydramnios is detected through the examination of ultrasound and can be explained in a subjective manner (For example, decreased amniotic fluid volume) Or numerically (for example, amniotic fluid index ≤5 cm, deepest single compartment below 2 cm) **(Keilman and Shanks, 2024)**.

Oligohydramnios may be classified as idiopathic or due to a maternal, foetal, or placental aetiology. The prognosis of the foetus is contingent upon a variety of circumstances, such as the gestational age at which oligohydramnios occurs, the severity of the condition (whether there is reduced or no amniotic fluid) and the underlying cause. Pregnancies that are complicated by oligohydramnios, regardless of the cause, are at risk for pulmonary hypoplasia the deformation of foetus and the compression of umbilical cord and owing to the critical function of a sufficient volume of amniotic fluid during the routine maturation of the lung and movement of the foetus, in addition to protecting the foetus and umbilical cord from any uterine compression. **(Figueroa et al., 2020)**.

Foetal morbidity and death are substantially elevated when amniotic fluid levels are diminished. Treatment and prenatal surveillance are facilitated by comprehension of the mechanisms that induce oligohydramnios. Spectral and pulsed waves Doppler is a non-invasive instrument utilized for screening the renal artery of the foetus. Doppler may offer some insight into oligohydramnios development during post-term pregnancy **(Ozkan et al., 2014)**.

Renal artery Doppler velocimetric measures may serve as an improved indirect indicator of foetal kidney function, as renal filtration and urine output are contingent upon arterial perfusion of the organ. In accordance with this concept, certain studies have evaluated the relationship among the pulsatility index of foetal renal artery (RA-PI) and the amniotic fluid level and **(Azpurua et al., 2009; Seravalli et al., 2019)**.

This study aimed to assess and establish the correlation among the foetal renal artery doppler and the volume of amniotic fluid indices in the pregnancy of post-term

Patients and Methods

This prospective comparison study was conducted on 68 post-term pregnant women who were enrolled in Benha University Hospitals.

Prior to inclusion in the study, patients were required to provide informed consent. A research ethics committee approval was received from the Benha Faculty of Medicine.

Inclusion criteria: Gestational age of at least 42 weeks, as determined by the last menstrual period verified through sonography during the first trimester, singleton pregnancies, age of 18 to 39 years, primi gravida cases, cases with a history of normal vaginal delivery, cases with an AFI of 5 cm or less (study group), and cases with a normal AFI of 5-25 cm (control group).

Exclusion criteria: Gestational age of at least 42 weeks, As confirmed by the first trimester sonography and the most recent menstrual cycle, singleton pregnancies, pregnancy age of 18 to 39 years, primi gravida cases, cases with a history of normal vaginal delivery, cases with an AFI of 5 cm or less (study group), and cases with a normal AFI of 5-25 cm (control group).

Methods: The following were administered to all pregnant women: a detailed history (Personal, Present, Menstrual, Obstetric, Past, Family, Contraceptive), clinical examination (General, Breast, Abdominal, and Obs), routine laboratory investigations (Complete blood count, Pt, Ptt, and INR, urine analysis), and sonographic assessment.

Technique of Doppler examination:

The patient was positioned in the position of left lateral, and the foetal abdomen axial image was obtained at the foetus kidney level. The renal artery of foetus was recognized through the use of colour flow Doppler imaging as it passed from aorta to kidney. I. Vessel straight section was recognized, and the doppler gate was subsequently installed through lumen. Achieving an insonation angle between 30° and 60° was our goal. Foetal breathing and movement were absent during the acquisition of all recordings. The GE volusoun P8 was employed to conduct measurements using a 3.5 MHz or 5.0 mHz probe. The foetal renal artery resistance index (RI), the index pulsatility (PI), the ratio of systolic/diastolic (S/D), the time of acceleration (AT), and the renal artery blood flow of foetus (FRABF) have been assessed. **(Azpurua et al., 2009)**.

Outcome measures

In post-term pregnancy: Doppler measures of the renal arteries and their correlation with oligohydramnios and normal amniotic volume.

We calculated the doppler of foetal renal arteries indices of the in both renal arteries (right and left) and documented the average of each indice.

The blood flow of renal artery was monitored inside its lumen prior to any emergent branches and at a distance from the aorta. At a rapid pace, the velocity waveform was captured using the filter of low pass (**Fig.1**). Index pulsatility (PI) was implemented as a metric for the impedance of blood flow distal to sampling site. The formula was employed to automatically calculate the PI. PI = s - d mean. The peak is denoted by s, the minimum by d, and the maximal mean of Doppler shift frequency over the cycle of cardio is the "average."

The formula R I = s − d s was used to automatically determine the resistance index (RI), in which denotes the peak systolic, d denotes the end-diastolic, c denotes the early diastolic, and x denotes the frequency of maximal diastolic. (**Fig.2**) **(Guedes-Martins et al., 2015).**

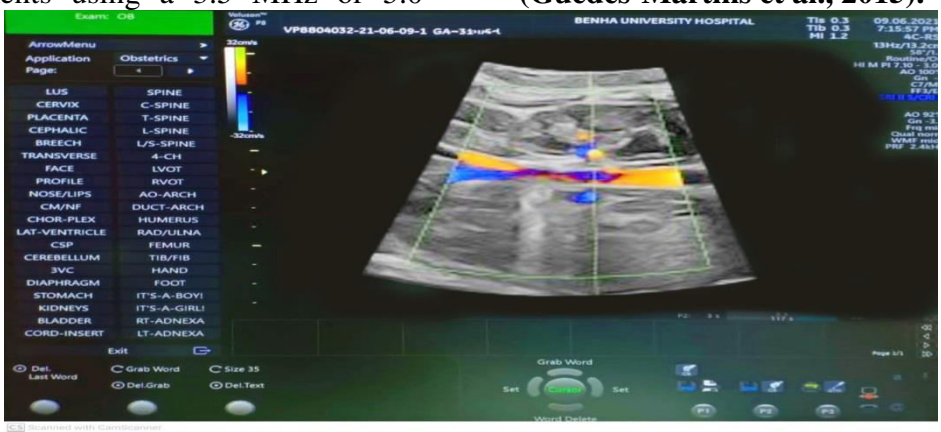

Fig.1. The fetal abdomen to allow identification of the abdominal aorta and its bifurcation at the level of the fetal kidneys.

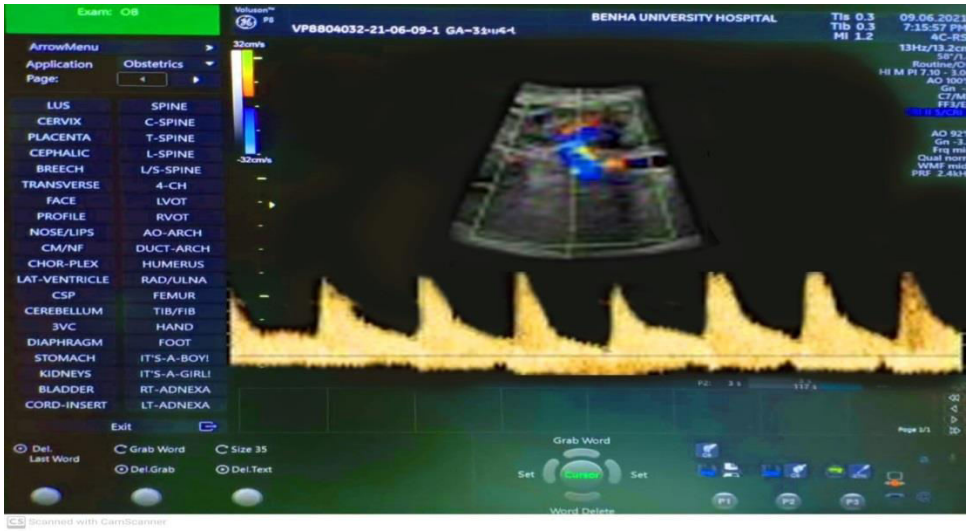

Fig.2. Doppler of a fetal renal artery in a case of oligohydramnios, 43 w, with PI of 2.1 and RI of 0.85.

Statistical analysis

The data that was collected was analysed and presented in appropriate graphs and tables (SPSS). Range and the mean ± SD expressed quantitative variables. Qualitative variables, such as percentage and frequency. $p<0.05$ is the threshold for significance.

Results

Among the study group and the control group, there was no statistically significant difference in terms of maternal age, gestational age, parity, and BMI (**Table.1**).

Table 1.Comparison between both groups regarding Demographic data.

Variables	Study group (34)	Control group (34)	P
Maternal age (years)	25.03± 2.34	25.15± 2.91	0.85
Gestational age (weeks)	43.01± 0.94	42.44± 0.62	0.63
Parity (median)	2	2	0.91
Body mass index (kg/ m^2)	27.74± 8.23	26.31± 4.91	0.43

The control group had an amniotic fluid index (AFI) of 11.82 cm, while the study group had an AFI of 3.94 cm. (**Table.2**).

Table 2. AFI between both groups.

Variable	Study group (34)	Control group (34)
AFI	3.94± 0.95	11.82 ± 3.58

Data is expressed as the mean ± SD.

A difference of statistically significant was observed among the group of study and the group of control. According to the doppler of Foetal Renal Artery indices RI, PI, PS, AT and FRABF (P=0.01, P=0.03, P= 0.01, P<0.0001). No statistically significant difference was observed among the group of control and the group of study in terms of the peak diastole of the embryonic renal artery (p=0.31), (**Table.3).**

Table 3. Comparison between both groups regarding Fetal Renal Artery Doppler Indices.

Variables	Study group (34)	Control group (34)	P
RI	0.85± 0.09	0.80± 0.05	0.01*
PI	2.19± 0.44	2.00± 0.23	0.03*
PS	43.82±20.18	31.23± 16.80	0.01*

PD	9.21± 6.50	7.83± 4.35	0.31
AT	0.09± 0.02	0.06± 0.01	<0.0001*
FRABF	58.24± 3.98	60.71± 3.25	0.01*

Data is expressed as the mean ± SD, RI: the index of Resistance. PI: Pulsatility index. PS: Peak systolic velocity. PD: Peak diastolic velocity. AT: Acceleration time. FRABF: Fetal renal artery blood flow. *: significant p value

Regarding correlation between AFI and other variants, A positive substantial correlation was identified among AFI and FRABF. Whilst a negative substantial correlation was identified between AFI and (RI, PI, PS, and AT). A significant positive correlation was not observed between AFI and (age, parity, and PD), (**Table. 4).**

Table 4. Correlation between AFI and other variants in all studied pregnancies.

Correlation with AFI	r	p
Age	0.04	0.72
Parity	-0.01	0.92
RI	-0.549**	0.00
PI	-0.330**	0.01
PS	-.258*	0.03
PD	-0.07	0.56
AT	-0.478**	0.00

Discussion

Amniotic fluid volume is a crucial indicator of fetal well-being during the second and third trimesters of pregnancy. It serves as a protective cushion for the fetus, regulates temperature, and aids in lung development. Normal amniotic fluid volume varies throughout pregnancy, but generally falls within a certain range. Oligohydramnios, a condition characterized by a deficiency in amniotic fluid (less than 500 mL), can arise in some pregnancies **(Refaat et al., 2022)**. Conversely, polyhydramnios occurs when the amniotic fluid volume exceeds 2000 mL **(Refaat et al., 2022)**. Both oligohydramnios and polyhydramnios are associated with potential risks for the fetus.

Our study group consisted of women with a mean age of 25.03 years (range: 20-28 years old). The mean gestational age at the time of the study was 43.01 weeks, ranging from 42 to 44 weeks. The average parity (number of previous pregnancies that resulted in a viable birth past 20 weeks) was 2.05, with a range of 1 to 4 pregnancies.

For comparison purposes, a previous study by **Ozkan et al. (2014)** reported a median maternal age of 23.7 years (range: 18.1-41 years) in their study group. Additionally, the median gestational age at Doppler ultrasound examination was 40.4 weeks (range: 40.1-41.3 weeks) **Ozkan et al., (2014)**. The average amniotic fluid index (AFI) in the study group was 3.94 cm, with a range of 2 to 5 cm.

In the study group, the mean RI was 0.85, with a range of 0.72 to 1.1, and the mean PI was 2.19, with a range of 1.60 to 2.40, as shown by the foetal renal artery doppler indices. The peak systolic and diastolic mean values were 43.82 and 9.21, respectively, with a range of 24.00 to 90.70 and 8.5 to 31.10, respectively. The AT and FRABF had a range of 0.06 to 0.12 and 51 to 64, respectively, with their respective averages of 0.09 and 58.24. The control group's mean age was 25.15 years, with a range of 20 to 30 years. The age of gestation ranged from 42 to 43 weeks, with a mean of 42.44 weeks. The mean parity was 2.09, with a range of 1 to 4. And a range of 18.1 to 41 years, median

mother age in the study was 23.7 years. The gestational age of median was 40.4 weeks at Doppler ultrasonography, with a range of 40.1 to 41.3 weeks. The gestational age of median at Doppler ultrasonography was 40.4 weeks, with a range of 40.1 to 41.3 weeks. Within the study group, the average amniotic fluid index (AFI) was 3.94 cm, with a range of 2 to 5 cm. The foetal renal artery doppler indices revealed that the mean RI in the study group was 0.85, with a range of 0.72 to 1.1, and the mean PI was 2.19, with a range of 1.60 to 2.40. The mean peak systole was 43.82 over the 24.00 to 90.70 range, while the mean peak diastole was 9.21, with a range of 8.5 to 31.10. In the 0.06 to 0.12 range, the mean AT was 0.09, and the mean FRABF was 58.24, with a range of 51 to 64. The control group mean age was 25.15 years, with a range of 20 to 30 years. The mean gestational age was 42.44 weeks, with a range of 42 to 43 weeks. The mean parity was 2.09, with a range of 1 to 4. The renal artery doppler of foetus indices revealed that the mean of control group's RI was 0.80, with a range of 0.71 to 0.87, and the mean PI was 2.00, with a range of 1.60 to 2.44. Peak diastole was 7.83, with a range of 5.10 to 19.00, while the mean of peak systole was 31.23, with a range of 22.00 to 70.40. The mean AT was 0.06, with a range of 0.05 to 0.0.9, and the mean FRABF was 60.71, with a range of 55 to 66.

Regarding age and parity, In the group of control and the group of experiment, no significant difference statistically was found. Significant differences statistically were found among the group of control and the group of study as indicated by the Foetal Renal Artery Doppler Indices RI, PI, Peak systole, AT, and FRABF (P=0.01, P=0.03, P= 0.01, P<0.0001).The group of control and the group of study didn't demonstrate a statistically significant difference in peak diastole of the renal artery of embryo (p=0.31). In **Ozkan et al., (2014)**, The median value of the PI of fetal renal artery was 2.1 (1.6–2.3), the RI was 0.83 (0.76–0.91), the S/D of fetal renal artery was 7.1 (6.3–8.7), and the AT was 0.07 (0.06–0.10 m/s2), according to the study. The average FRABF was 64.0 ± 6.0 mL/min.

In terms of the association between AFI and other variations, a negative substantial correlation was established among AFI and (RI, PI, Peak systole, and AT), while a major positive correlation was found among AFI and FRABF.A positive significant correlation was not observed among AFI and (age, peak diastole and parity). According to **Refaat et al., (2022)** Intermittent shock Correlations among the velocity of the flow waveforms of renal artery and the amniotic fluid index are demonstrated by Doppler ultrasonography. Whatever the diagnosis, whether it is normal, oligohydramnios, or polyhydramnios. In the third trimester, a raise in the PI of Renal Artery value is associated with a decrease in AFI (Oligohydramnios). This may be interpreted as a signal to expedite delivery to protect the fetus's life. Changes in renal artery PI values could be employed to foresee oligohydramnios. Renal artery PI readings were reduced in pregnancies with elevated AFI (Polyhydramnios).

In accordance with our research, **Ozkan et al. (2014)** examined 84 singleton, post-term pregnancies that were well-documented and referred to the obstetric service of high post-term pregnancy Oligohydramnios was detected in 41 patients (48.1 percent). The S/D, RI, and AT of patients with oligohydramnios were elevated. The blood flow of fetal renal artery (FRABF) was lower than in those without oligohydramnios (p = 0.037). Utilizing renal artery Doppler indices, FRABF was the most singular significant predictor of oligohydramnios in stepwise logistic regression: p = 0.012, p < 0.005 [odds ratio = 0.821, 95 percent confidence interval (CI) = 0.769–0.912].

The increased renal artery of fetus RI is suggestive of a pathophysiological resemblance to intrauterine growth restriction. Oligohydramnios is a condition that is widely recognized and is characterized by reduced fetal growth. Rightmire observed that studies of doppler demonstrated the most favorable performance of statistics in his examination of the published literature **(Leibovitch et al., 2012)**.

This serves as additional proof that oligohydramnios are characterized by substantial hemodynamic modifications. The inclusion of instances with prenatal development deficit due to other causes, as opposed to fetal hypoxia, is a potential confounding element in such investigations. The present investigation removed cases that were known to be related with fetal growth limitation due to underlying maternal illnesses. Consequently, the potential for confusion regarding the reason of the Doppler alterations was reduced **(Ozkan et al., 2014)**.

Leibovitch et al. have demonstrated that the APGAR scores of patients with oligohydramnios are not statistically distinct. During the fifth and tenth minutes, there were no differences in APGAR scores between the two groups. The pregnancies in our study group were devoid of complications beyond oligohydramnios. In other terms, the population of patients consisted of singleton pregnancies with isolated oligohydramnios. This improves the value of studies by allowing the population to present objective findings regarding the correlation among oligohydramnios and fetal renal Doppler indices **(Leibovitch et al., 2012)**.

Our findings, which are supported by the literature, validate of fetal renal arteriography doppler importance indicators in oligohydramnios prediction. We discovered that RI, PI, AT, and FRABF were significantly different in post-term pregnancies with oligohydramnios and related to AFI, although earlier research claimed that only RI was a factor **(Oz et al., 2002)**.

May AT and FRABF **(Ozkan et al., 2014),** are correlated with AFI in pregnancies with gestational ages of 42 weeks or above, whereas our study was conducted on pregnancies with gestational ages of 42 weeks or higher.

Conclusion

The use of Doppler ultrasonography has revealed a correlation between oligohydramnios and the flow velocity waveforms of renal arteries. Oligohydramnios is distinguished by substantial fluctuations in RI, PI, AT, and FRABF levels, which function as a metric for rapid delivery to ensure the fetus's survival. In post-term pregnancies with decreasing amniotic fluid volume, foetal renal artery Doppler measurement should be incorporated into the daily clinical obstetric practise.

Limitations

To verify the findings of this investigation, other investigations need be conducted with a substantial sample size.

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