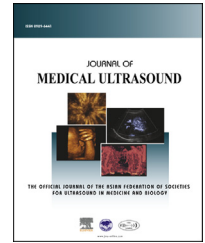




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ORIGINAL ARTICLE

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



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Objective: The aim of the study was to investigate the fetal renal artery impedance and hemodynamics in the context of post-term pregnancy with oligohydramnios, using Doppler indices. **Methods:** This is a prospective study which took place between December 2011 and March 2013. Fetal renal artery Doppler was performed in women at gestational age between 40.1 weeks and 41.3 weeks with singleton pregnancies. The fetal renal artery Doppler resistance index (RI), pulsatility index (PI), systolic/diastolic ratio (S/D), acceleration time (AT), blood flow (BF), fetal renal volume, APGAR, and cesarean ratio were measured. Stepwise logistic regression and the two-tailed *t* test were used to determine whether the Doppler indices correlated with oligohydramnios (amniotic fluid index < 5 cm).

Results: We studied 84 well-dated, singleton, post-term pregnancies, referenced from the high post-term pregnancy obstetric service. Forty-one patients (48.1%) had oligohydramnios. Patients with oligohydramnios had higher S/D, RI, and AT. The fetal renal artery BF (FRABF) was lower in patients with oligohydramnios than those without oligohydramnios ($p = 0.037$). Stepwise logistic regression using renal artery Doppler indices found FRABF to be the only significant predictor of oligohydramnios: $p = 0.012$, $p < 0.005$ [odds ratio = 0.821, 95% confidence interval (CI) = 0.769–0.912].

Conclusion: In oligohydramnios in the context of post-term pregnancies, there is an increased resistance in the fetal renal vascular bed. The reduced FRABF suggests that increased arterial impedance is an important factor in the development of oligohydramnios. This study supports the idea of increased vascular resistance in the fetal renal bed in patients in post-term

Conflicts of interest: All contributing authors declare no conflicts of interest.

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pregnancies. We think that fetal renal artery Doppler measurement should be part of a routine daily clinical obstetric practice in post-term pregnancies with oligohydramnios.

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Introduction

In the presence of decreased amniotic fluid, fetal morbidity and mortality significantly increase [1]. Understanding the mechanisms responsible for the development of oligohydramnios is useful for treatment and antenatal surveillance. Pulsed and spectral wave Doppler serves as a noninvasive method for patient screening. The fetal renal artery Doppler may provide some insights into the development of oligohydramnios during post-term pregnancy [2].

Several studies have evaluated fetal renal artery Doppler parameters (systolic and end-diastolic velocities), but the mechanisms leading to oligohydramnios in post-term pregnancies are still a mystery. Despite the significance of amniotic fluid volume in post-term pregnancy assessment and perinatal outcome, however, the mechanism of the development of oligohydramnios remains uncertain and controversial [3]. Some authors do not agree the mechanism of redistribution of blood flow (BF) away from the fetal kidney [4], or increased fetal renal tubular sensitivity to some local vasodilators as the etiology of oligohydramnios during post-term pregnancy [5]. The purpose of the current study is to determine the relationship of renal perfusion and reduced amniotic fluid volume in post-term pregnancy.

Materials and methods

This prospective, observational study of 84 patients at gestational age between 40.1 weeks and 41.3 weeks was conducted between December 2011 and May 2013. All women in the cohort group carried a singleton post-term pregnancy. Gestational age was established by the last menstrual period and confirmed by the first trimester sonography. Patients with medical complications known to affect fetal growth, such as diabetes, chronic hypertension, or other vascular disorders, and patients with imprecise dates or the diagnosis of fetal growth restriction as an indication for testing, were excluded from the study. Oligohydramnios is defined by amniotic fluid volume which is <5 cm. Doppler measurements were performed by two radiologists. The patient was placed in the left lateral position, and an axial image of the fetal abdomen was obtained at the level of the fetal kidneys. Using color flow Doppler imaging, the fetal renal artery was identified as it approached the kidney from the aorta. A straight segment of the vessel was identified and the Doppler gate placed within the lumen of the vessel. We attempted to obtain an angle of insonation between 30° and 60° . All recordings were obtained in the absence of fetal breathing and movement. Measurements were performed with a 3.5 MHz or 5.0 MHz probe using Toshiba Logic S6. The fetal renal artery resistance index (RI), pulsatility index (PI), systolic/diastolic ratio (S/D), acceleration time (AT), and fetal renal

artery BF (FRABF) were measured. The FRABF was measured by the unit of mm per minute. The renal volume is calculated by the equation $a \times b \times c \times 0.5$. The APGAR scores at the 5th and 10th minutes were recorded. The cesarean ratio is calculated in both groups. We therefore evaluated the correlation between this index and amniotic fluid index. Post-term pregnancy and neonatal outcome were ascertained after delivery by reviewing the appropriate medical records. The neonatal kidney volume was measured in the first 15 days of the life. The groups were compared using the two-tailed *t* test. Normality of distribution of the Doppler indices was confirmed using the Kolmogorov-Smirnov test. The Spearman correlation coefficient was used for nonparametric values. Stepwise multiple logistic regression was performed to determine which Doppler index significantly predicted oligohydramnios. The Mann-Whitney U test was used for the comparison of $p < 0.05$ which was considered to be statistically significant.

All patients gave informed consent and the study protocol was approved by the Hospital Research Ethics Committee.

Results

There were a total of 106 cases in the cohort group. Twenty-two patients were excluded from the study; eight because of the lack of knowledge at the birth and 14 patients had findings of chronic hypoxia, and intrauterine growth restriction. The median maternal age was 23.7 years (18.1–41 years). The median gestational age at Doppler ultrasound was 40.4 (40.1–41.3) weeks. The median birth weight was 3619 g (3075–4240 g). The median value of the fetal renal artery PI was 2.1 (1.6–2.3), RI was 0.83 (0.76–0.91), fetal renal artery S/D was 7.1 (6.3–8.7), and the AT was 0.07 (0.06–0.10 m/s^2). The mean FRABF was 64.0 ± 6.0 mL/min. The patients were referred from high-risk post-term pregnancy clinics. The study group was thought to be similar to the hospital's overall delivery population, which is approximately 50% middle class, the remainder being in the low gained population. There were no perinatal deaths.

Regarding the results; in the context of the amnion fluid index, there was a negative correlation with maternal age ($r = -0.29$, $p = 0.012$), fetal renal artery S/D ratio ($r = -0.364$, $p = 0.032$), fetal renal artery RI ($r = -0.420$, $p = 0.021$), and fetal renal artery AT ($r = -0.434$, $p = 0.016$) and a positive correlation with fetal weight ($r = 0.325$, $p = 0.025$), neonatal fetal renal volume ($r = 0.451$, $p = 0.0370$), and FRABF ($r = 0.246$, $p = 0.026$).

For the neonatal renal volume there was a positive correlation with amnion fluid index ($r = 0.534$, $p = 0.014$), FRABF ($r = 0.598$, $p = 0.023$), and a negative correlation with fetal renal artery RI ($r = -0.254$, $p = 0.041$), fetal

renal artery AT ($r = -0.57, p = 0.029$), and with fetal renal artery S/D ratio ($r = -0.352, p = 0.036$).

Regarding the data of fetal renal volume, there was a negative correlation with fetal renal artery RI ($r = -0.230, p = 0.010$) and fetal renal artery AT ($r = -0.281, p = 0.001$) and a positive correlation with amnion fluid index ($r = 0.216, p = 0.015$), FRABF ($r = 0.212, p = 0.017$) and with neonatal renal volume ($r = 0.237, p = 0.008$). The detailed statistical analysis of the amnion fluid index with other parameters is shown in Table 1.

The statistical analysis for the fetal renal volume is shown in Table 2. The 50 percentile of the fetal renal volume was 33 cc.

In the cohort group, when the amnion fluid index is divided in the basis of the percentiles, the 50% is 42. There were 41 patients with AFI < the 50% percentile (48.8%) and 43 cases with AFI > the 50% percentile (51.1%). In the oligohydramnios group, the fetal weight was lower than in the group without oligohydramnios ($p = 0.018$). The difference between the PI in both groups was not statistically significantly different ($p = 0.430$). The Apgar scores at the 5th 10th minutes were not different in both groups. Caesarean section rates in both groups were around 30%, and were not statistically significant. The cesarean ratio was higher in both groups. The fetal renal artery RI, S/D ratio, and AT were higher than the control group ($p = 0.024, p = 0.017$, and $p = 0.028$, respectively). FRABF was lower in the oligohydramnios than in the control group ($p = 0.037$).

Stepwise logistic regression (using fetal renal artery RI, PI, S/D ratio, AT, fetal renal volume, FRABF, fetal weight,

Table 2 Statistical analysis results of fetal renal volume and other parameters in the oligohydramnios group and the control group.

	FRV > %50	FRV < %50	<i>p</i>
Gestational age (wk)**	40.2 (40.1–41.3)	40.3 (40.1–41.2)	0.021
AFI**	48.0 (42.0–111.0)	45.0 (41.0–47.7)	0.025
RAPI**	2.03 (1.60–2.31)	2.08 (1.68–2.28)	0.641
RARI**	0.81 (0.76–0.91)	0.84 (0.78–0.90)	0.029
RASD**	7.28 (6.30–8.48)	7.45 (6.54–8.70)	0.627
RAAT**	0.08 (0.06–0.09)	0.09 (0.08–0.10)	0.003
RABF*	64.60 ± 7.50	59.20 ± 8.31	0.325
Fetal weight (g)**	3610.0 (3075.0–4240)	3520.0 (3120.0–4100)	0.158
APGAR at 5 th min	9 (8–10)	9 (7–10)	0.174
APGAR at 10 th min	9 (9–10)	9 (9–10)	0.258
Cesarean ratio	20 (30.3%)	17 (28.3%)	0.482

* Mean ± standard deviation.

** Median (IQR).

AFI = amnion fluid index; FRV = fetal renal volume; RAAT = fetal renal artery acceleration time; RABF = fetal renal artery blood flow; RAPI = fetal renal artery pulsatility index; RARI = fetal renal artery resistivity index; RASD = fetal renal artery systolic/diastolic ratio.

Table 1 Statistical analysis of the amnion fluid index in the oligohydramnios group and the control group.

	AFI > %50	AFI < %50	<i>p</i>
Gestational age (wk)**	40.4 (40.1–41.2)	40.5 (40.1–41.3)	0.212
RAPI**	2.09 (1.60–2.28)	2.15 (1.68–2.31)	0.430
RARI**	0.82 (0.76–0.89)	0.85 (0.81–0.91)	0.024
RASD**	7.31 (6.30–8.48)	7.55 (6.54–8.70)	0.017
RAAT**	0.07 (0.06–0.09)	0.09 (0.08–0.11)	0.028
RABF*	65.30 ± 7.340	58.02 ± 9.04	0.037
Fetal weight (g)**	3621.0 (3075–4240.0)	3550.0 (3150–4100)	0.032
Fetal renal volume (cc)**	34.5 (32.94–38.1)	33.7.0 (31.9–37.4)	0.031
APGAR at 5 th min	9 (8–10)	9 (7–10)	0.132
APGAR at 10 th min	9 (9–10)	9 (9–10)	0.351
Cesarean ratio	21 (32.6%)	17.3 (31.3)	0.451

* Mean ± standard deviation.

** Median (IQR).

AFI = amnion fluid index; RAAT = fetal renal artery acceleration time; RABF = fetal renal artery blood flow; RAPI = fetal renal artery pulsatility index; RARI = fetal renal artery resistivity index; RASD = fetal renal artery systolic/diastolic ratio.

and neonatal renal volume as the independent variables) found that only FRABF was a significant predictor of oligohydramnios [$p = 0.01$, odds ratio = 0.821, 95% confidence interval (CI) = 0.761–0.912]. The fetal renal artery RI was significantly lower in the group with oligohydramnios [mean (standard error) = 58.02 ± 9.04 versus 65.30 ± 7.34, $p = 0.012$, respectively].

Discussion

In this study, we demonstrate the relationship between fetal renal artery parameters in pregnancies in the third-trimester with oligohydramnios. A reduction of FRABF below the mean was associated with a statistically significant increase in the risk of oligohydramnios.

There are several potential mechanisms by which changes in the kidney can cause oligohydramnios in post-term pregnancies. Fetal hypovolemia and hemoconcentration due to changes in the placental fetal fluid balance, as proposed by Rightmire and Campbell, is one such mechanism [6]. Bar-Hava et al [7] mentioned that oligohydramnios can be the result of excessive tubular reabsorption of urine due to above-normal sensitivity to vasopressin in pregnancies. With regards to a radiologic approach to the potential mechanism, the localized increase in impedance in the fetal renal vessels can be measured using Doppler parameters. The study results reported here appear consistent with this mechanism. Our findings support the finding of Veille et al [8], who found elevated fetal renal artery S/D

ratios in pregnancies with oligohydramnios. In normal placental function, oligohydramnios was likely to be caused by a decrease in fetal urine production as a consequence of an increase in intrafetal renal vascular resistance. This could be affected by the intrafetal renal production or release of local vasodilator or vasoconstrictor substances involved in autoregulation.

There were studies in the literature similar to our results. However, Rizzo et al did not detect a significant correlation between the fetal renal artery PI and the quantity of amniotic fluid. These authors mentioned that the amniotic fluid volume was related more to the reabsorptive capabilities of the kidney than to decreased fetal renal blood perfusion [9]. This hypothesis depends on animal studies. There was an increased sensitivity of the fetal kidney to vasopressin, which is a local mediator of the resulting mechanism of vasospasm at the vascular bed.

In 1996, Weiner et al [10] demonstrated that reductions in amniotic fluid volume are associated with changes in cardiac velocity waveforms, and concluded that left ventricular output is reduced in fetuses with oligohydramnios. This might be caused by an increase in systemic peripheral resistance and suggest deterioration of the fetal renal vascular bed. In our opinion, this might explain the decrease in the fetal renal vascular bed in patients with oligohydramnios. In the presence of an increase in the vascular bed, the AT should be higher with oligohydramnios, which is similar to our results.

The finding of a reduced birth weight in oligohydramnios cases, and increased fetal renal artery RI, indicates a similarity in the pathophysiology to intrauterine growth restriction. Reduced fetal growth is a well-recognized complication in oligohydramnios. Rightmire analyzed the published literature and mentioned that Doppler studies had the best statistical performance [11]. This provides further evidence that significant hemodynamic changes are a feature of oligohydramnios. A potential confounding variable in such studies is the inclusion of cases with fetal growth impairment due to other causes, apart from fetal hypoxia. In the current study, we eliminated cases with underlying maternal disorders known to be associated with fetal growth restriction, thus reducing the potential for confusing the cause of the Doppler changes.

Patients with oligohydramnios do not have statistically different APGAR scores, which is mentioned by Leibovitch et al [12]. There are no differences between both groups with regards to APGAR scores within the 5th and 10th minutes. In our study group, the pregnancies did not have problems other than oligohydramnios. In other words, the patient population consisted of isolated oligohydramnios singleton pregnancies. This makes the study more valuable, because the population can have a potential for showing objective results of the relationship between oligohydramnios and fetal renal Doppler indices.

There are some limitations of the study relating to blood urinary nitrogen. We were not able to correlate the Doppler findings with the neonatal period blood urinary nitrogen, and follow up the neonatal infants for urinary system infection.

In literature, this is the first publication that combines the fetal renal artery AT and the renal blood volume mL/minute. The only statistically significant parameter between the oligohydramnios and the Doppler indices is the fetal renal artery Doppler flow. A lower renal artery BF under the mean value increases the probability of developing oligohydramnios. The fetal renal artery Doppler could be used in clinical daily practice.

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