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Doppler velocity of fetal renal arteries in case of oligohydramnios

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Abstract
Background: Oligohydramnios is a relatively common complication of pregnancy and such a case is often encountered in clinical practice. Oligohydramnios is often to describe pregnancies with AFI <5 and borderline/ low normal amniotic fluid volume to describe pregnancies with AFI 5 to 8 (4) Alternatively, some clinicians prefer the single vertical pocket (SVP) with severe oligohydramnios defined as SVP less than 1 and mild oligohydramnios defined as SVP 1 to 2 Aim of this current study sought to determine the relation of fetal renal artery Doppler with normal pregnancies and pregnancies complicated by oligohydramnios.
Methods: Sample size was 50 patients in the 2nd trimester; they subdivided into two groups based on the amount of the amniotic fluid as follow:
Group I: Control group (AFI 5-25) N = 25 cases.
Group II: Oligohydramnios group (AFI less than 5) N = 25 cases.
All patients in this study subjected to the following:
Ultrasound study: Measurement of fetal biometry, Detection of congenital malformation. And Amniotic fluid index measurement.
Doppler study: Renal artery (RA) and Umbilical artery (UA).
Results: There was statistically significant difference between groups according to Renal and umbilical artery Doppler indices PI & RI in Gestational Age 26 weeks, statistically significant difference over the periods through renal artery Doppler indices RI, statistically significant difference over the periods through umbilical artery Doppler indices PI in each group and Renal Artery PI Which was 2.681, with sensitivity of 44.6% specificity of 53% with diagnostic accuracy of 47%, (p-value >0.05 NS). Renal Artery RI Which was 0.989, with sensitivity of 43.5% specificity of 43% with diagnostic accuracy of 33%, (p-value >0.05 NS). Umbilical Artery PI Which was 1.044, with sensitivity of 42.1% specificity of 39.5% with diagnostic accuracy of 29.7%, (p-value >0.05 NS). Umbilical Artery RI Which was 0.645, with sensitivity of 48.5% specificity of 42.1% with diagnostic accuracy of 41.6%, (p-value >0.05 NS).
Conclusions: We recommend introducing renal artery resistance index as auxiliary ante partum test for women with Amniotic fluid abnormalities in addition to other ante partum fetal wellbeing tests to predict fetuses at risk of hypoxia.

Keywords: Doppler velocity, fetal renal arteries, oligohydramnios

Introduction
Oligohydramnios is a relatively common complication of pregnancy and such a case is often encountered in clinical practice [1]. It refers to amniotic fluid volume that is less than expected for gestational age. It is typically diagnosed by ultrasound examination and may be described qualitatively (e.g, normal, reduced) or quantitatively (e.g., amniotic fluid index [AFI] <5) [2] Diminished fluid volume may be found often with pregnancies that continue beyond term [3].
Oligohydramnios is often to describe pregnancies with AFI <5 and borderline/ low normal amniotic fluid volume to describe pregnancies with AFI 5 to 8 [4]. Alternatively, some clinicians prefer the single vertical pocket (SVP) with severe oligohydramnios defined as SVP less than 1 and mild oligohydramnios defined as SVP 1 to 2 [5]. An adequate volume of amniotic fluid is critical to allow normal fetal movement and growth and to cushion the fetus and umbilical cord [6]. Oligohydramnios may inhibit these processes and can lead to fetal deformation, umbilical cord compression and death [7].
Reported rates of oligohydramnios are influenced by variations in diagnostic criteria, the population studied (low or high risk, screening or indicated ultrasound examination), the

threshold used and the gestational age at the time of the ultrasound examination (preterm, term or post-term) [8].
A higher rate of isolated oligohydramnios (24%) will be detected in a study in term 8 and this is double incidence as compared to other studies [9]. The AFV of 135 women will be evaluated between 70 women (52%) in the upper greater group that will be established by AFI and 65 women (48%) in the lower greater AFI group [9].
The current study sought to determine the relation of RA and umbilical artery (UA) flow velocity waveforms in normal pregnancies and pregnancies complicated by oligohydramnios. Aim of this current study sought to determine the relation of fetal renal artery Doppler with normal pregnancies and pregnancies complicated by oligohydramnios

Patients and Methods
Department of Obstetrics and Gynecology, Tanta University Hospitals during March 2019 until March 2020 and may be extended if needed.

Inclusion criteria
- Pregnant women aged between 20-35 years old
- Pregnant women BMI between 24.9-34.9
- Pregnant women with no special habits
- Pregnant women with single viable fetus
- Gestational weeks between 14-26

Exclusion criteria
- Congenital anomalies.
- Patient with medical disorders complicating the pregnancy and who had type I, II and gestational diabetes and;
- Rupture of fetal membranes.

Sample Size
Sample size was 50 patients in the 2nd trimester; they subdivided into two groups based on the amount of the amniotic fluid as follow;
Group I: Control group (AFI 5 – 25) N = 25 cases
Group II: Oligohydramnios group (AFI less than 5) N = 25 cases

Study Instruments
All patients in this study subjected to the following
Ultrasound study
A. Measurement of fetal biometry including:
- Biparaital diameter (BPD), occipito-frontal diameter (OFD), head circumference (HC), femur length (FL).
- Abdominal circumference (AC) and
- Transverse abdominal diameter (TAD).

B. Detection of congenital malformation.
C. Amniotic fluid index measurement
Technique of ultrasound
- A four quadrant amniotic fluid volume assessed by placing the ultrasound transducer perpendicular to the wall of the uterus and parallel to the mother's spine in four abdominal quadrants and measuring the largest vertical amniotic fluid pocket. Pockets consisting primarily of umbilical cord disregarded. A four quadrant sum of 5 or greater considered normal.
- AFI less than 5 classified as oligohydramnios while measurements from 5-25 accepted as normal values for the control group.

Doppler study
Fetal arteries flow velocity waveforms assessed using color and pulse wave Doppler studies of the desired vessel to obtain the resistance index (RI). The high pass filter set at the minimum and the pulse repetition frequency 2.5KHz. An average of five consecutive Doppler velocity wave forms used for analysis.
The sample volume 2-4mm. By use of the color flow mapping system, the Doppler cursor placed in the lumen of the desired vessel. The flow velocity waveforms recorded during fetal inactivity periods. The angle between the Doppler beam and the vessel under examination kept <30 degrees. The resistance index (systolic-diastolic/ systolic) calculated from the frozen image of three separately obtained cardiac cycles and then averaged.

A. Renal artery (RA)
Doppler parameters for the fetal renal arteries measured close to the level of the abdominal aorta outflow. Measurements obtained from both kidneys kidney in each fetus. An axial image of the fetal abdomen obtained at the level of the fetal kidneys. A longitudinal view of the fetal kidney obtained first, the color flow mapping function then superimposed and the renal artery imaged.
The pulsed Doppler cursor then placed at the level of the artery's origin from the abdominal aorta, velocity waveforms recorded during periods of fetal apnea, and RI calculated. A minimum of three consecutive waveforms used to calculate the PI and RI.

B. Umbilical artery (UA)
The patients placed in a semi-recumbent position with left lateral tilt, then the uterine contents quickly scanned with real time ultrasound in order to select an area of the amniotic cavity with several loops of umbilical cord.
Using pulsed wave Doppler, the characteristic sound and shape of the umbilical artery waveform demonstrated and identified. When the screen showed several waveforms of similar height, the image frozen and the peak systolic frequency, end-diastolic frequency, resistance index estimated.
A minimum of 3 separate readings averaged before the final values obtained. Because of the potential effect of fetal breathing movements on waveform variability, recording performed during periods of fetal apnea.

Statistical analysis
SPSS statistics for windows (Statistical Package for the Social Sciences) version 26 (IBM, Armonk, NY, USA) was used for statistical analysis of the collected data. Shapiro-Wilk test was used to check the normality of the data distribution. All tests were conducted with 95% confidence interval. P (probability) value < 0.05 was considered statistically significant. Quantitative variables were expressed as mean and standard deviation while categorical variables were expressed as frequency and percentage. One-way ANOVA with Bonferroni post hoc analysis and Kruskal Wallis with Dunn's post hoc analysis tests were used for inter-group comparison of parametric and non-parametric continuous data respectively. Categorical Group differences with Fisher exact and Chi square tests were used for inter-group comparison of nominal data. Bivariate Correlations were assessed using Pearson's or Spearman's correlation coefficient depending on the nature of data. Sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and accuracy were calculated using the receiver operating characteristic (ROC) curve. A binary logistic regression model was conducted to determine the value of platelet indices in prediction of abortion (R2).

Results

In a comparison between groups according to demographic data; Age and parity showed no statistically significant while there was statistically significant difference between groups according to birth weight.

Table 1: Comparison between groups according to demographic data

Demographic Data	Group I: Normal (N=25)	Group II: Oligohydramnios (N=25)	Test	p-value
Age (years)				
Mean± SD	25.920±3.237	26.851±3.127	F=0.051	0.950
Range	23-35	23-34		
Parity				
Median (IQR)	2 (2)	3 (1)	H=0.618	0.683
Range	0-5	0-4		
Birth weight (gm)				
Mean± SD	3392.17±479.67	3048.75±305.01	F=4.673	<0.001**
Range	2898-3723	2483-3473		

F: A one-way analysis of variance (ANOVA) H: Kruskall Wallis H test
SD: Standard deviation; IQR: Interquartile range

As shown in table (2), there was no statistically significant difference between groups according to Renal and Umbilical artery Doppler indices in Gestational Age 14 weeks.

Table 2: Comparison between groups according to Renal and Umbilical artery Doppler indices in gestational age 14 weeks

Gestational Age 14 weeks	Group I: Normal (N=25)	Group II: Oligohydramnios (N=25)	Anova	p-value
Renal artery				
PI				
Mean± SD	2.779±0.173	2.851±0.181	0.867	0.451
Range	2.0-3.2	2.5-3.2		
RI				
Mean± SD	0.975±0.002	0.983±0.003	1.613	0.113
Range	0.973-0.986	0.979-0.996		
Umbilical artery				
PI				
Mean± SD	1.133±0.044	1.179±0.048	2.023	0.067
Range	1.05-1.22	1.1-1.27		
RI				
Mean± SD	0.665±0.037	0.681±0.046	0.705	0.331
Range	0.60-0.70	0.62-0.74		

F: A one-way analysis of variance (ANOVA); SD: Standard deviation
PI: Pulsatility index; RI: Resistance index

This table shows no statistically significant difference between groups according to Renal and umbilical artery Doppler indices RI in Gestational Age 22 weeks.

Table 3: Comparison between groups according to Renal and Umbilical artery Doppler indices in Gestational Age 22 weeks

Gestational Age 22 weeks	Group I: Normal (N=25)	Group II: Oligohydramnios (N=25)	ANOVA	p-value
Renal artery				
PI				
Mean± SD	2.189±0.113	2.823±0.161	4.141	0.121
Range	2.03-2.87	2.31-3.13		
RI				
Mean± SD	0.987±0.002	0.991±0.001	0.533	0.237
Range	0.983-0.989	0.988-0.994		
Umbilical artery				
PI				
Mean± SD	1.077±0.061	1.161±0.053	1.403	0.071
Range	0.96-1.1	1.05-1.31		
RI				
Mean± SD	0.643±0.032	0.673±0.031	2.997	0.132
Range	0.54-0.69	0.64-0.73		

*Statistically significant. F: A one-way analysis of variance (ANOVA); SD: Standard deviation. PI: Pulsatility index; RI: Resistance index

This table shows statistically significant difference between groups according to Renal and umbilical artery Doppler indices PI & RI in Gestational Age 26 weeks.

Table 4: Comparison between groups according to Renal and Umbilical artery Doppler indices in Gestational Age 26 weeks

Gestational Age 26 weeks	Group I: Normal (N=25)	Group II: Oligohydramnios (N=25)	Anova	p-value
Renal artery				
PI				
Mean± SD	2.013±0.102	2.731±0.155	1.250	0.028
Range	2.01-2.67	2.2-3.10		
RI				
Mean± SD	0.985±0.003	0.993±0.002	1.167	0.013
Range	0.981-0.987	0.986-0.991		
Umbilical artery				
PI				
Mean± SD	1.036±0.044	1.077±0.051	6.551	0.011*
Range	0.95-0.98	0.99-1.2		
RI				
Mean± SD	0.631±0.017	0.667±0.031	6.791	0.006*
Range	0.54-0.66	0.62-0.71		

F: A one-way analysis of variance (ANOVA); SD: Standard deviation
*Statistically significant. PI: Pulsatility index; RI: Resistance index

This table shows statistically significant difference over the periods through renal artery Doppler indices PI.

Table 5: The extent of the difference over the periods through Renal Artery Doppler indices (PI) in the each group

Renal artery (PI)	Group I: Normal (N=25)	Group II: Oligohydramnios (N=25)
Gestational Age 14 weeks	2.779±0.173	2.851±0.181
Gestational Age 22 weeks	2.189±0.113	2.823±0.161
Gestational Age 26 weeks	2.013±0.113	2.731±0.155
ANOVA	3.412	
p-value	0.013*	

*Statistically significant difference between intra group visits

This table shows statistically significant difference over the periods through renal artery Doppler indices RI.

Table 6: The extent of the difference over the periods through Renal Artery Doppler indices (RI) in the each group

Renal artery (RI)	Group I: Normal (N=25)	Group II: Oligohydramnios (N=25)
Gestational Age 14 weeks	0.975±0.002	0.983±0.003
Gestational Age 22 weeks	0.987±0.002	0.991±0.001
Gestational Age 26 weeks	0.985±0.003	0.993±0.002
ANOVA	3.948	
p-value	0.015*	

*Statistically significant difference between intra group visits. F: A one-way analysis of variance (ANOVA) RI: Resistance index

This table shows statistically significant difference over the periods through umbilical artery Doppler indices PI in each group.

Table 7: The extent of the difference over the periods through Umbilical Artery Doppler indices (PI) in the each group

Umbilical artery (PI)	Group I: Normal (N=25)	Group II: Oligohydramnios (N=25)
Gestational Age 14 weeks	1.133±0.044	1.179±0.048
Gestational Age 22 weeks	1.077±0.061	1.161±0.053
Gestational Age 26 weeks	1.036±0.044	1.077±0.051
ANOVA	6.152	
p-value	<0.001*	

* Statistically significant difference between intra group visits
F: A one-way analysis of variance (ANOVA) PI: Pulsatility index

Receiver operating characteristics (ROC) curve was used to define the best cut off value of

Renal Artery PI

- Which was 2.681, with sensitivity of 44.6% specificity of 53% with diagnostic accuracy of 47%, (p-value >0.05 NS).

Renal Artery RI

- Which was 0.989, with sensitivity of 43.5% specificity of 43% with diagnostic accuracy of 33%, (p-value >0.05 NS).

Umbilical Artery PI

- Which was 1.044, with sensitivity of 42.1% specificity of 39.5% with diagnostic accuracy of 29.7%, (p-value >0.05 NS).

Umbilical Artery RI

- Which was 0.645, with sensitivity of 48.5% specificity of 42.1% with diagnostic accuracy of 41.6%, (p-value >0.05 NS).

Table 8: Diagnostic Performance of renal artery and umbilical artery in Discrimination of Oligohydramnios.

Gestational Age 26 weeks	Cut-off	Sens.	Spec.	PPV	NPV	Accuracy
Renal artery						
PI						
Normal and Oligo.	2.681	44.6%	53.0%	78%	38.2%	47.0%
RI						
Normal and Oligo.	0.989	43.5%	43.0%	58%	44.4%	33.0%
Umbilical artery						
PI						
Normal and Oligo.	1.044	42.1%	39.5%	54.9%	43.1%	29.7%
RI						
Normal and Oligo.	0.645	48.5%	42.1%	67.4%	36.7%	41.6%

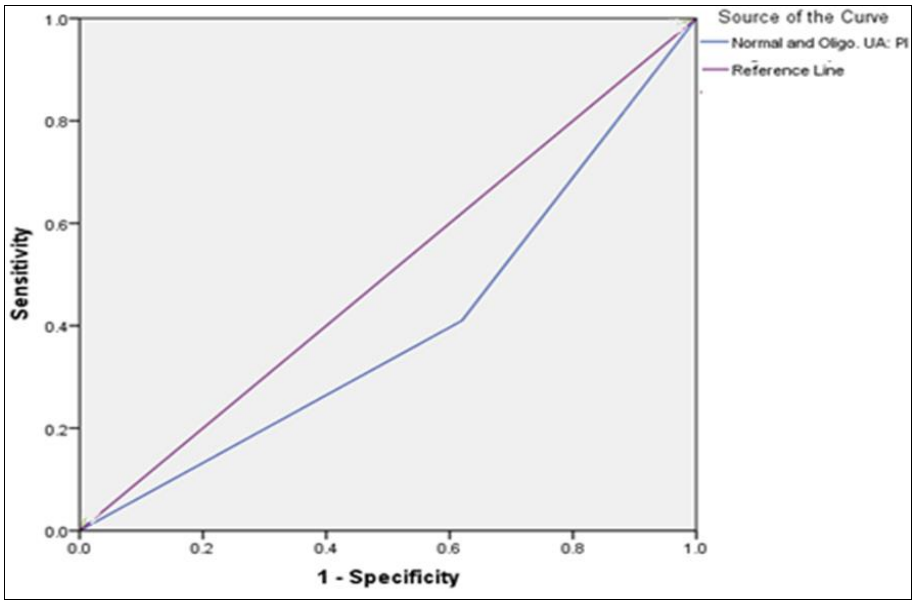

Fig 1: ROC curve diagnostic performance of umbilical artery PI in Discrimination of Oligohydramnios.

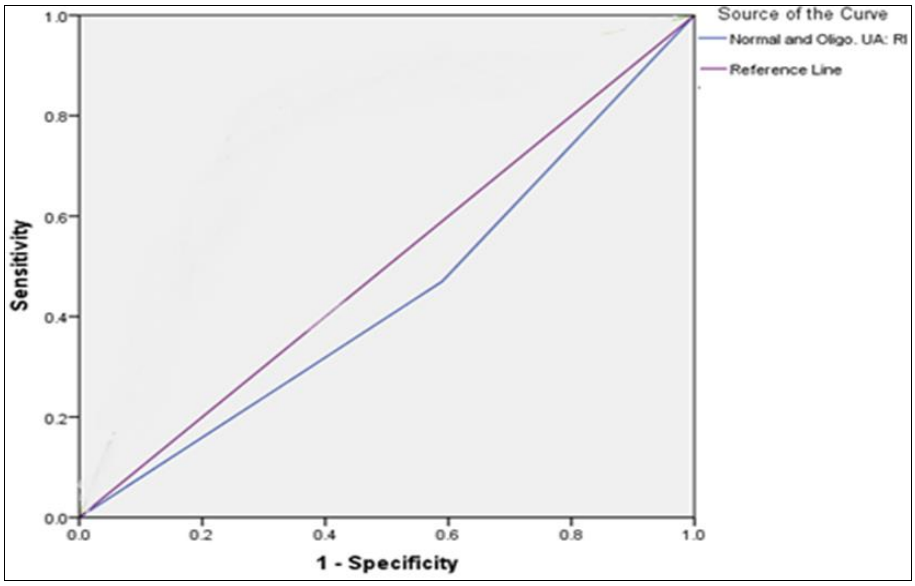

Fig 2: ROC curve diagnostic performance of umbilical artery PI in Discrimination of Oligohydramnios.

Discussion

Amniotic fluid abnormalities (oligohydramnios and polyhydramnios) are the leading cause of fetal morbidity and mortality. Assessment of amniotic fluid index provides information about the fetal kidneys and allows evaluation of fetal circulation. Thus, starting from the early stages of gestation, intermittent evaluation of renal artery flow may be used to predict changes of amniotic fluid dynamics [10].

Renal and umbilical artery Doppler values were evaluated at 14, 22 and 26 weeks' gestation in 300 low-risk pregnant women with singleton pregnancies. Pulsatility index (PI) and resistance index (RI) were recorded and the amniotic fluid volume was evaluated. Three groups were formed according to the amniotic fluid volume at birth. Group I consisted of 264 pregnant women with normal amniotic fluid, group II included 30 pregnant women with oligohydramnios and group III included six

pregnant women with polyhydramnios. Doppler parameters were compared between the groups and within each group according to gestational age. Renal artery PI values were higher in group II than group I at 14, 22 and 26 weeks. The PI value at 28 weeks' gestation was statistically significant (P = 0.011). At 28 weeks' gestation, group II also had higher umbilical artery PI and RI values than group I. An increase in renal artery PI develops in early pregnancy before the development of oligohydramnios.

In comparison with a study done by Akin *et al*. (2013), there were differences between our results and there results. Their aims were to investigate the relationship between fetal renal artery Doppler results and pregnancy outcomes in patients with idiopathic abnormal amniotic fluid indices. A total of 110 patients without signs of fetal distress were included in the study: 31 idiopathic oligohydramnios and 29 idiopathic polyhydramnios pregnancies (study group) and 50 normal pregnancies (controls). Doppler investigation of the umbilical artery (UA), and fetal renal artery (RA) was performed in all patients. Fetal RA resistive index (RI) and pulsatile index (PI) values were measured. Values pertaining to type of birth, newborn weight and APGAR scores were compared [11].

Doppler of fetal outcome further large sample-sized studies on the subject sought to be carried out. Oz *et al*., studied 147 well-dated, singleton, post term pregnancies, of which 21 (14.3%) had oligohydramnios. He observed reduced renal artery end-diastolic velocity in fetal renal artery. He suggests that increased arterial impedance is an important factor in the development of oligohydramnios in prolonged pregnancies [12].

In comparison with a study done by Özkan *et al*. (2014), there were differences between our results and there results. 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. 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) [13].

They 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] (167). They concluded that 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 [14].

Conclusions

There is a statistical difference decrease regarding PI in the control group normal AFI at 14, 22 and 26 weeks. There is a statistical significant decrease in PI in the control group (normal AFI at 14, 22, and 26 weeks). An increase in RA PI develops in early pregnancy before the development of oligohydramnios. In pregnancies developing polyhydramnios, RA PI was lower.

We recommend introducing renal artery resistance index as auxiliary ante partum test for women with Amniotic fluid abnormalities in addition to other ante partum fetal wellbeing tests to predict fetuses at risk of hypoxia.

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Nil

Conflict of Interest
Nil

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