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Part of Isolated Polyhydramnios Can Be Explained By Renal Artery Doppler: A Prospective Case-Control Study

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ABSTRACT

To investigate the effect of renal artery Doppler (RAD) parameters on the increase in fetal urine production and identify potential associations with isolated polyhydramnios.

This prospective case-control study was conducted at a single tertiary center. A total of 84 patients were included. Patients were grouped into patients with polyhydramnios and patients with normal AFI. RAD parameters were evaluated for each patient.Spearman correlation coefficient was used. The "ROC" curve was used to determine the cut-off value for predicting isolated polyhydramnios.

A significant difference was observed in the systolic/diastolic ratio between the isolated polyhydramnios group and the control group (p=0.03). The cut-off value for renal artery S/D ratio in predicting isolated polyhydramnios was determined as 4.96 with 73% sensitivity and 58% specificity. In spearman correlation test, S/D ratio showed a moderate positive correlation with AFI.

Isolated polyhydramnios is correlated with S/D, one of the RAD parameters. Based on the S/D ratio, we can say that isolated polyhydramnios is of renal origin.

Keywords: Polyhydramnios, Doppler, Renal Artery, amniotic fluid

Introduction

The incidence of polyhydramnios in the general obstetric population typically ranges between 1% and 2% (1). The diagnosis of polyhydramnios is established when the amniotic fluid index (AFI), as measured via ultrasound, is ≥24 cm, or when the single deepest pocket (SDP) measurement is ≥8 cm. Isolated polyhydramnios is diagnosed by excluding conditions known to result in polyhydramnios, such as maternal diabetes, congenital anomalies of the central nervous system or gastrointestinal system, alloimmunization, fetal infections (e.g., cytomegalovirus and toxoplasmosis), placental tumors, or multiple gestations (2,3). Isolated polyhydramnios refers to a condition in which fetal or maternal factors are excluded and only an increase in amniotic fluid is seen. While 15% of polyhydramnios is caused by diabetes and 15% by fetal anomalies, the cause of 70% of polyhydramnios cannot be determined in the fetal period (4,5).

The volume of amniotic fluid reflects the balance between fluid production and the movement of fluid out of the amniotic sac. The most common mechanisms underlying polyhydramnios are increased fetal urination and decreased fetal swallowing (6).

Our aim in this study is to find a parameter that will reveal the cause of isolated polyhydramnios, which occupies a large place in the etiology of polyhydramnios, and to use this parameter in prenatal counseling.

Materials and Methods

Study Population: This study was conducted between September 2024 and December 2024 at the Perinatology Clinic of Ankara Bilkent City Hospital

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and included patients who were referred due to idiopathic polyhydramnios between 24 and 40 weeks of gestation and a control group with normal AFI measurements. The study is a prospective case-control study.

Informed consent was obtained from each participant, and ethical approval was granted by the Ethics Committee of Ankara Bilkent City Hospital (TABED 2-24-184). The study adhered to the principles outlined in the Declaration of Helsinki at every stage.

The AFI values, gestational ages, gravidity, parity, and RAD parameters (peak systolic velocity [PSV], systolic/diastolic ratio [S/D], pulsatility index [PI], resistive index [RI], and time-to-maximum velocity [T_{max}]) of the patients included in the study were recorded. In this study, the patients included in the control group were selected from healthy foetuses without amniotic fluid abnormalities who presented to our outpatient clinic on the same dates.

Excluded from the study were patients with multiple pregnancies, organ transplants, immune deficiencies, hypertension, or diabetes, those with known major fetal chromosomal or structural anomalies, and those with incomplete data or inaccessible records.

Ultrasonographic Examination: Patients were evaluated between the 24th and 40th weeks of gestation, during which isolated polyhydramnios had been diagnosed. Each patient was assessed once by the same maternal-fetal medicine specialist (B.B.Ö.), under the supervision of an experienced maternal-fetal medicine professor (D.S.). Examinations were performed using the Voluson S10 and E8 device (GE Healthcare, Milwaukee, Wisconsin, USA) with a 2-5 MHz convex probe.

AFI was calculated by summing the four quadrants, with a total value of 240mm or above considered diagnostic of polyhydramnios. The isolated nature of all patients in the study group was confirmed through detailed ultrasound findings and oral glucose tolerance test results. Biometric measurements were taken, and the fetal kidney was visualized in the coronal plane (figure1) [6]. A color Doppler was placed on the kidney closest to the probe, with the aorta and renal arteries identified. The renal artery (RA) was identified by the red color indicating blood flow toward the probe. Spectral Doppler was used to assess the RA, with calipers set to 2–3 mm and the insonation angle kept as close to 0 degrees as possible. Doppler measurements of the PS, RI, PI, S/D, and T_{max} of the RA were recorded (figure 2) (6).

Statistical Analysis: Sample size was calculated using G Power software (version 3.1; Franz Foul, University of Kiel, Kiel, Germany). For sample size determination, a p-value of 0.05 (two-tailed) and 95% power with an effect size of 0.80 (large) were used. A sample size of 54 patients per group was calculated.

Data analysis was performed using SPSS v. 22.0 (SPSS Inc., Chicago, IL, USA). The Kolmogorov-Smirnov and Shapiro-Wilk tests were used to assess the normality of the data distribution. The Mann-Whitney U test was employed to compare non-normally distributed variables. Descriptive analyses were undertaken using median, minimum, and maximum values for non-normally distributed data. Spearman correlation coefficient was used.The "ROC" curve was used to determine the cut-off value for predicting idiopathic polyhydramnios. A p- value<0.05 was considered statistically significant.

Results

The study included a total of 84 patients, comprising 42 patients diagnosed with isolated polyhydramnios and 42 patients in the control group. The demographic and clinical characteristics of the patients, including age, gravidity, parity, gestational weeks, and RAD parameters, are presented in Table 1. There were no significant differences between the two groups in terms of age, gravidity, parity, or gestational age. When comparing the RAD parameters between the two groups, no significant differences were observed in PSV, PI, RI, T_{max} values ($p > 0.05$). However, the S/D ratio was significantly different between the two groups (4.75(1.08-16.12) vs.6.98 (1.95-34.50) $p = 0.003$) (table 1).

The demographic and clinical characteristics, including age, gravidity, parity, AFI, and RAD parameters of both subgroups, are detailed in Table 1. The two subgroups did not differ significantly in terms of age, gravidity, parity, or gestational weeks ($p>0.05$).

As a result of the ROC analysis, the cut-off value for renal artery S/D ratio in predicting was determined as 4.96 with 73% sensitivity and 58% specificity (AUC: 0.704 p:0.003) (Figure 3).

In spearman correlation test, S/D ratio showed a moderate positive correlation with AFI (r:0.267, P:0.046) (table 2).

Table 1: Demographic and Clinical Characteristics of The Patients With Isolated Polyhydramnios and Controls

Variables	Control group (n = 42)	Isolated polyhydramnios (n = 42)	P value
Age	26.0 (22.0–38.0)	29.0 (20–39)	0.145
Gravida	2.0 (1.0–7.0)	2.0 (1.0–8.0)	0.836
Parity	1.0 (0.0–5.0)	1.0 (0.0–4.0)	0.619
Gestational week	33.2 (25.6–37.3)	34.4 (25.1–35.1)	0.441
RA-PSV	43.91 (15.2–76.63)	45.18 (19.26–67.47)	0.785
RA-S/D	4.75 (1.08–16.12)	6.98 (1.95–34.50)	0.003
RA-PI	1.89 (0.83–7.87)	2.21 (1.34–16.42)	0.250
RA-RI	0.86 (0.56–1.48)	0.88 (0.70–1.51)	0.687
RA-Tmax	20.11 (3.44–29.28)	18.38 (2.02–30.98)	0.651

PI: pulsatility index, PSV: peak systolic velocity, RA: renal artery, RI: resistive index, S/D: systolic/diastolic ratio, , T_{max}: time-to-maximum velocity
Mann Whitney U test was performed. P<0.05 was accepted as significant.

Table 2: Spearman Correlation Between AFI and Renal Artery Doppler Parameters

Variables	AFI	
	r	*p*
RA-PSV	0.372	0.215
RA-S/D	0.267	0.046
RA-PI	0.168	0.182
RA-RI	0.075	0.552

r: correlation coefficient, statistically significant at p < 0.05
AFI: amniotic fluid index, PI: pulsatility index, PSV: peak systolic velocity, RA: renal artery, RI: resistive index, S/D: systolic/diastolic ratio, , T_{max}: time-to-maximum velocity
Spearman Correlation was performed. P<0.05 was accepted as significant.

Table 3: ROC" curve for S/D Ratio For Prediction of Isolated Polyhydroamnios

	Std.			Asymptotic 95% Confidence Interval	
Area	Errora	Asymptotic Sig.b	Cut-off	Lower Bound	Upper Bound
,704	,061	,003	4.96	,584	,824

Discussion

This study aimed to determine the effect of renal artery Doppler (RAD) parameters on the increase in fetal urine production and identify any findings that could reveal a relationship with isolated polyhydramnios. In addition, to contribute to prenatal patient counseling and to provide prenatal guidance to postnatal pediatricians to examine diseases that increase renal arterial blood flow.

Common Doppler indices used in obstetrics are peak systolic (S) to end diastolic (D) flow ratio (S/D), pulsatility index (PI = S-D/average flow rate over the cardiac cycle), resistance index (RI = ((S-D)/S) (12). These doppler parameters are used in many areas of fetal life (7).

Renal filtration and urine production are closely linked to renal arterial perfusion, suggesting that RAD parameters might serve as more accurate indicators of fetal renal function [6].

There are no studies in the literature investigating renal artery in isolated polyhydramnios however there are several studies in the literature examining the correlation between fetal RAD indices and amniotic fluid levels, including both oligohydramnios and polyhydramnios, but the findings are inconsistent. For instance, a study on isolated oligohydramnios identified RI as the most accurate Doppler parameter related to isolated oligohydramnios (8). Another study comparing

Fig. 1. Ultrasonographic demonstration of renal artery doppler examination

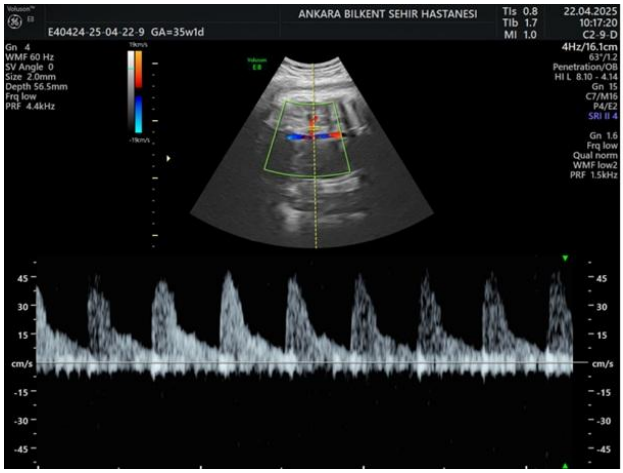

Fig. 2. Fetal renal artery doppler waveform demonstration

AFI with RAD indices found an inverse relationship between AFI and RA-PI (9). Research evaluating RAD and umbilical artery Doppler values in low-risk pregnancies demonstrated elevated RA-PI values in pregnancies with oligohydramnios, increasing even before the onset of oligohydramnios (10). Two other studies on post-term pregnancies with oligohydramnios revealed that renal arterial impedance increased in the presence of oligohydramnios, suggesting that RAD is a better predictor of oligohydramnios compared to umbilical artery Doppler (11,12). In contrast, some studies have not observed such a relationship. For example, one study reported significantly lower fetal RA-PI in the borderline AFI group compared to the normal AFI group (13). In the renal artery doppler study performed in pregnancies complicated with preeclampsia, S/D ratio and PSV value were found to be significantly lower than the control group patients (14).

In another study conducted on pregnant women with preeclampsia, they found a lower S/D ratio and a lower RI value in pregnant women with preeclampsia. No significant difference was found

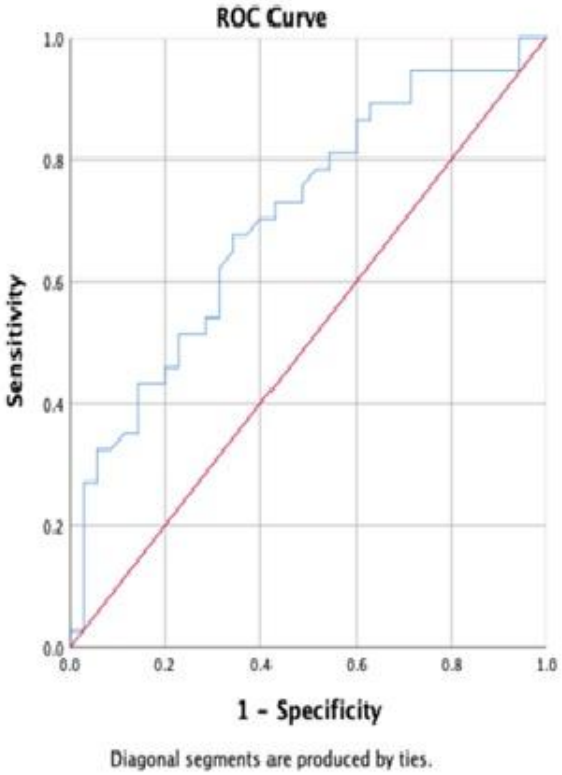

Fig. 3. ROC curve for S/D ratio for prediction of isolated polyhydramnios

in PI (15).

In the literature, many studies of oligohydramnio have examined the relationship between RAD parameters and amniotic fluid; however, results have been inconsistent."

Cerebroplacental PI and Renal artery PI values were compared in pregnant women with isolated oligohydramnios and no significant difference was found in PI values (16).

In another study looking at RAD parameters in pregnant women diagnosed with isolated oligohydramnios before the 37th week of gestation, no significant difference was found in the renal artery PI index compared to the control group (17).

Another study evaluating RA-PI values across isolated oligohydramnios, oligohydramnios, and normal groups found no difference in PI multiple of the median values (18). Furthermore, a paper on prolonged pregnancies identified a significant relationship between AFI and the fetal renal S/D ratio (19). A group of researchers attributed the conflicting results across studies on the relationship between PI and AFI to the influence of vascular bed size and organ size on vascular

resistance. They introduced a new index by adjusting RI for renal volume and called this volume-adjusted RA-PI, which proved to be a better predictor of oligohydramnios than unadjusted RA-PI or RA-PI adjusted for gestational age. However, this new index was not effective in predicting polyhydramnios [20]. Another study found no significant difference in fetal RA-PI before and after conservative treatment for polyhydramnios, indicating that this parameter could not be used as a marker for the evaluation of polyhydramnios (21).

The majority of the above-mentioned studies have focused on oligohydramnios, with limited research on polyhydramnios. In our study, S/D index was higher than in the control group and S/D ratio was correlated with AFI. S/D had a cutt off value in predicting polyhydramnios. There was no significant difference in PI value.

The limitations of this study stem from the relatively small sample size.

In conclusion, isolated polyhydramnios is associated with S/D, one of the RAD parameters. Based on the renal artery S/D ratio, we can say that isolated polyhydramnios is of renal origin. Based on this, we think that etiologies that will increase renal blood flow after birth should be investigated in fetuses with high S/D ratio in isolated polyhydramnios. More patients are needed to support our study.

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