Fetal Renal to Abdominal Ratio: A Constant Measurement Throughout Gestation

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ABSTRACT:
Background: Sonographic assessment of the fetal kidneys is an integral part of the prenatal anatomical survey.
Objectives: To evaluate the fetal renal to abdominal (RTA) ratio throughout pregnancy and to investigate whether this ratio can be a potential diagnostic landmark for congenital anomalies of the kidney and urinary tract (CAKUT).
Methods: Measurements of the anterior-posterior diameters of the fetal kidney and fetal abdomen (APAD) were obtained prospectively. The RTA was calculated as the ratio between them in in two groups: normal population vs. CAKUT cases. RTA in CAKUT cases was compared to RTA in a normal population.
Results: The study group was comprised of 210 women. The mean gestational age for the fetuses was 31 ± 5.6 weeks (range 14–40 weeks). Fetal RTA ratio was found to be 0.28 ± 0.03 throughout pregnancy from early second trimester to term, with high reproducibility of measurements. During the study period the RTA was evaluated in nine cases referred for suspected CAKUT. All cases demonstrated a different ratio according to the renal anomaly. High ratio was observed in one case of overgrowth syndrome (Beckwith Wiedenmann syndrome; 0.47), three cases of infantile polycystic kidney (0.45–0.47), and three cases of a solitary kidney (0.31–0.35), while cases of dysplastic kidneys revealed a low ratio (0.14–0.18).
Conclusions: Prenatal RTA is constant throughout gestation. An abnormal ratio should lead to meticulous renal investigation to rule out kidney disease.

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KEY WORDS: renal to abdominal ratio, congenital anomalies of the kidney and urinary tract (CAKUT), ultrasound, prenatal diagnosis

Fetal renal assessment is based on evaluating the location, size, parenchyma, and collecting system [4,5].

Size is especially important since small sized kidneys may be the first indicator of renal hypoplasia or dysplasia; both carrying a risk for reduced renal function and hypertension at later stages of life because of low nephron endowment in fetal life [6-9]. However, large sized kidneys may be related not only to overgrowth syndromes such as Beckwith–Wiedenmann syndrome (BWS) but also to inherited ciliopathies in which progressive renal injury and deterioration in renal function are inevitable.

Fetal renal nomograms assess three parameters (longitudinal, anterior-posterior, and transverse renal lengths) throughout gestation and are currently the main customary tool for biometric reference for prenatal renal assessment [10-13]. In two studies published in 1980 and 1994, the ratio of the circumference of the fetal kidney to the circumference of the fetal abdomenal circumference was evaluated [14,15]; however, this procedure did not become part of routine renal assessment.

The aim of the present study was to assess the ratio of the anterior posterior diameters of the kidney and the abdomen during pregnancy and to investigate whether this simple ratio can serve as a diagnostic landmark for screening CAKUT and putative inherited renal disease.

PATIENTS AND METHODS

A prospective study was conducted in the prenatal diagnostic unit at the Sheba Medical Center over a period of 8 months. The study was approved by the clinical ethics committee, and informed consent was received from all patients.

POPULATION

Inclusion criteria for renal to abdominal ratio (RTA) assessment in the normal population included a normal obstetric course, absence of maternal disease, a singleton pregnancy, good dating (last menstruation confirmed by first trimester ultrasound examination), estimated fetal weight (EFW) within the 10th to 90th percentile, and a normal sonographic anatomical scan.

C ongenital anomalies of the kidney and urinary tract (CAKUT) constitute approximately 20–30% of all anomalies diagnosed during prenatal surveys [1-3].

Prenatal diagnosis of CAKUT enables a multidisciplinary team to rule out associated anatomical anomalies, sequences, and genetic syndromes and to offer a better treatment plan for the future parents.

RTA in pathological cases was measured in cases referred for suspected renal anomaly. The measurement was not assessed in cases associated with hydronephrosis. All patients in whom a CAKUT anomaly was observed were referred to a specialist in pediatric nephrology and a geneticist, and they were followed throughout pregnancy.

Figure 1. Normal renal to abdominal ratio of 0.28 at 25 weeks of gestation

Figure 2. Distribution of RTA ratio as a function of gestational age demonstrating a constant ratio of 0.28
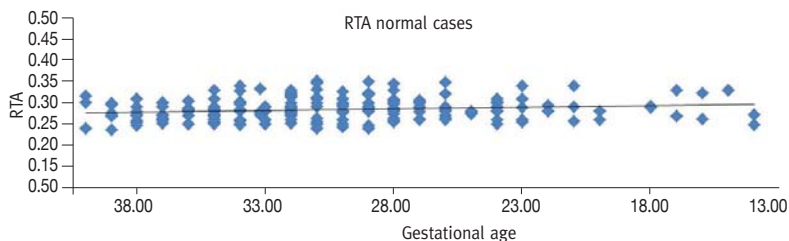
RTA = renal to abdominal

Figure 3. [A] A case of autosomal recessive polycystic kidneys at 27 weeks of gestation demonstrating a RTA ratio of 0.45, [B] A case of dysplastic kidneys at 34 weeks of gestation demonstrating a RTA ratio of 0.14
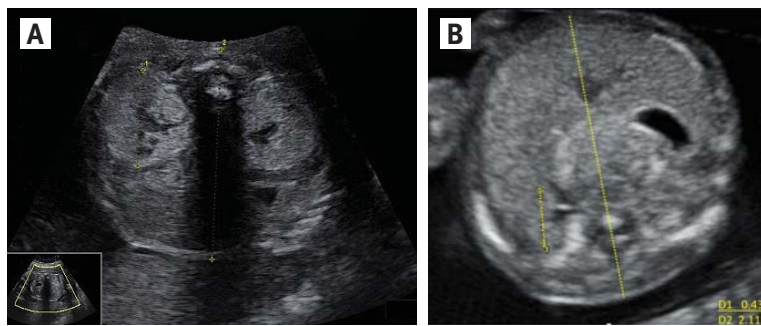
RTA = renal to abdominal

MEASUREMENTS

All scans were performed using a Voluson E8 (GE Medical systems, Kretz Ultrasound, Zipf, Austria) with a trans-abdominal transducer of 4-8 MHz or a 5-9 MHz trans-vaginal probe.

Sonographic examinations were performed during routine sonographic follow-up from 14 to 40 weeks of gestation.

RTA was calculated as a ratio of the anterior-posterior diameters of the fetal kidney and of the abdomen (APAD) measured in an axial view, at the level of the kidneys and pelvis [Figure 1].

RTA in CAKUT cases was compared to the data from RTA measurements in the normal population.

To evaluate reproducibility of measurements, an arbitrary sample of 30 fetuses was evaluated twice by the first operator and then by a second operator blinded to the measurements obtained by the first operator.

STATISTICAL ANALYSIS

Data were collected using Microsoft Excel 2010 software (Microsoft Corp, Richmond, CA). Statistical analyses were performed using IBM Statistical Package for the Social Sciences statistics software, version 23 (SPSS, IBM Corp, Armonk, NY, USA).

Gestational age and RTA are described as mean ± standard deviation.

Estimates of intra-class correlation coefficient (ICC) were used to explore inter- and intra-agreement between the two operators. Agreement was considered slight when ICC ≤ 0.2, fair when $0.2 < ICC ≤ 0.4$, moderate when $0.4 < ICC ≤ 0.6$, substantial when $0.6 < ICC ≤ 0.8$, and almost perfect when ICC > 0.8. For assessing agreement between the two measurements, we used a Bland-Altman plot. Paired and unpaired Student's *t* tests were used to evaluate the difference between two measurements of one examiner and between the means of two examiners, respectively.

RESULTS

NORMATIVE DATA

The study was comprised of 210 women. The mean fetal gestational age was 31 ± 5.6 weeks (range 14–40 weeks).

The RTA ratio was constant at 0.28 ± 0.03 throughout gestation [Figure 2].

Nine cases were examined for suspected CAKUT. All CAKUT cases demonstrated a different RTA according to the renal anomaly. A high ratio was observed in one case of BWS (0.47), three cases of infantile polycystic kidney (0.45–0.47), [Figure 3] and three cases of solitary kidney (0.31–0.35). Two cases of dysplastic kidneys revealed a low ratio (0.14–0.18).

REPRODUCIBILITY OF MEASUREMENTS

Intra-observer variability

The mean difference between two measurements by a single observer was 0.0042 (95% confidence interval [95%CI]

-0.0035–0.0123), no significant difference was found between the two measurements (paired *t*-test, *P* = 0.264). The ICC was 0.956 (95%CI 0.915–0.978, *P* < 0.001. The Bland-Altman scatter plot demonstrated the intra observer variability with most of the values between ± 1.96 SD [Figure 4].

Inter-observer variability

The mean difference between two examiners was 0.0056875 (95%CI -0.0210077–0.0323827). This difference was not significant (independent *t*-test, *P* = 0.672). The ICC was 0.724 (95%CI 0.433–0.865), *P* < 0.001.The Bland-Altman scatter plot demonstrates the inter observer variability with most of the values between ± 1.96 SD.

DISCUSSION

In this study, we report a constant RTA ratio throughout gestation, which can be practically applied for screening of renal anomalies. The measurement was found to be precise and easy to perform with good reproducibility. A constant ratio throughout gestation makes it a practical tool in cases in which an abnormal renal parenchymal volume is suspected.

An abnormal RTA should lead to further sonographic renal assessments and to a multidisciplinary investigation and counseling by a pediatric nephrologist and a geneticist. Fetal renal assessment is based on evaluating the location, size, parenchyma, and collecting system. Fetal renal nomograms throughout gestation were published for three dimensions: length, anterior posterior, and transverse [10-13]. Two previous reports measured the ratio between abdominal and renal circumferences [14,15]; however, this ratio did not become a customary part of the fetal renal and urinary tract anatomical survey. It is possible that measuring the kidney circumference and abdominal circumference in different planes is less precise and more time consuming than measuring the AP diameter of the kidney and abdomen in the same plane in one snapshot evaluation.

Patients with unilateral multi cystic kidney dysplasia (MCKD) or unilateral renal agenesis have a congenital solitary functioning kidney that is compensatory enlarged [16]. The question whether this enlargement is due to increased nephron numbers and/or nephron hypertrophy is unresolved. This question is of clinical importance since hypertrophy is associated with a risk of developing hypertension and proteinuria later in life with consequent development of chronic renal disease and cardiovascular disease. In case of unilateral renal agenesis or MCKD, contra-lateral compensatory kidney enlargement is considered a good prognostic sign as increased nephrogenesis has been shown to occur in the solitary kidney [17]. A large RTA may reassure that the compensatory nephrogenic mechanisms are intact.

A small RTA measurement could possibility indicate dysplastic kidneys and should be followed by detailed renal assessment and close surveillances throughout pregnancy to rule out renal hypoplasia.

Figure 4. **[A]** Intra-observer variability, **[B]** Inter-observer variability

CONCLUSIONS

RTA is a practical and reproducible measurement that has been found to be constant from the second trimester throughout pregnancy and may be used as a supplementary tool for fetal kidney sonographic evaluation.

Larger studies should assess the ratio in large population CAKUT cases and inherited renal anomalies.
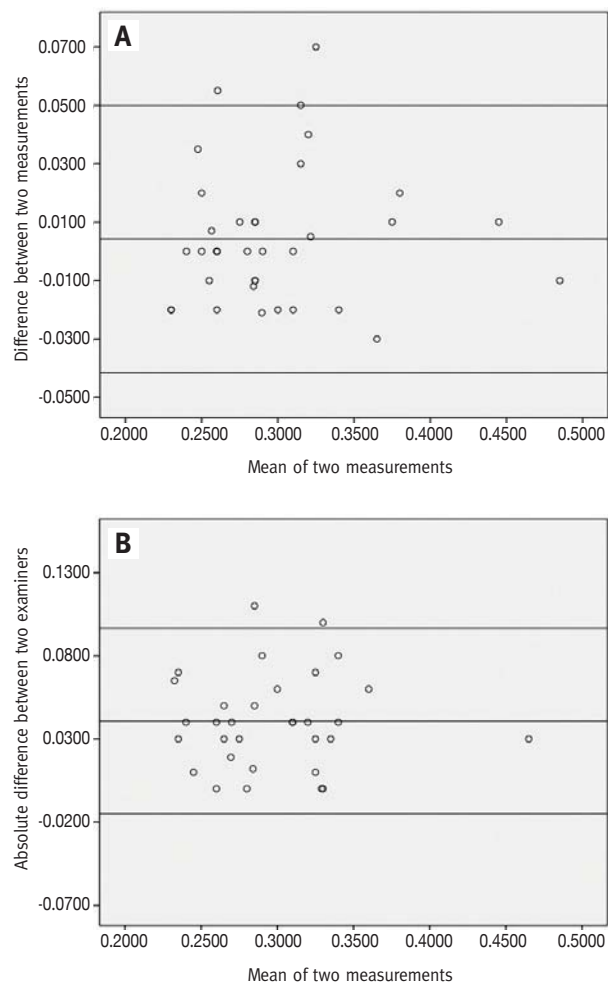
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Capsule

Contribution of socioeconomic status to racial/ethnic disparities in adverse pregnancy outcomes among women with systemic lupus erythematosus

Kaplowitz and colleagues examined rates of adverse pregnancy outcomes (APO) by race/ethnicity among women with systemic lupus erythematosus (SLE), with and without antiphospholipid antibodies (aPL), and whether socioeconomic status (SES) accounted for differences. The frequency of APO in Caucasian women with SLE, with and without aPL was 29% and 11%, respectively. For African American and Hispanic women it was approximately twofold greater. In African American women with SLE alone, adjustment for clinical variables attenuated the odds ratio (OR) from 2.7 (95% confidence interval [95%CI] 1.3–5.5) to 2.3 (95%CI 1.1–5.1), and after additional adjustment for SES, there were no longer significant differences in APO compared to

Caucasians. In contrast, in SLE patients with aPL, Caucasians, African Americans, and Hispanics had markedly higher risks of APO compared to Caucasian SLE patients without aPL (OR 3.5 [95% CI 1.4–7.7], OR 12.4 [95% CI 1.9–79.8], and OR 10.4 [95% CI 2.5–42.4], respectively), which were not accounted for by clinical or SES covariates. The authors conclude that this finding suggests that for African American women with SLE without aPL, SES factors are key contributors to disparities in APO, despite monthly care from experts, whereas other factors contribute to disparities in SLE with aPL.

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Eitan Israeli

Capsule

Prescribing for children with rheumatic disease: perceived treatment approaches between pediatric and adult rheumatologists

Van Mater et al. compared practice patterns and prescribing differences for juvenile idiopathic arthritis (JIA) between adult rheumatologists (ARs) and pediatric rheumatologists (PRs), the perceived educational needs, and factors that enhance or impede co-management. Two parallel, cross-sectional surveys focusing on JIA were administered in 2009 to a random sample of 193 PRs and 500 ARs using the American College of Rheumatology membership file. Bivariate analysis was conducted for common items. The response rate was 62.1% for ARs (n=306) and 72.3% for PRs (n=138). Nearly one-quarter of surveyed ARs care for children with JIA, with most limiting their practice

to older children. There was more discomfort in treating JIA than diagnosing it, and there were significant prescribing differences. Both provider types identified the need for better dosing and treatment resources. Updated management guidelines along with exposure to pediatric rheumatology in fellowship could reduce treatment differences and enhance the care of children with JIA. Shared medical records and improvement in reimbursement may optimize co-management.

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Eitan Israeli