The Effect of Fluid Intake on Renal Length Measurement in Adults

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ABSTRACT: Purpose. To evaluate whether oral fluid intake has an effect on renal length as determined with sonography.

Methods. We studied 524 adult patients who were referred to our ultrasound unit with complaints other than urinary tract symptoms. The mean age of the patients was 44 years (range 17–76). All of the measurements were performed with the patient in the prone position. The renal length of each kidney was measured by the same observer before and after oral fluid intake. Student’s t-test was applied for the statistical significance of renal length measurements before and after hydration. Analysis of variance was performed for the effect of age and sex on the renal length measurements.

Results. The mean renal length on the right side was 106.2 ± 6.5 mm and 107.5 ± 6.7 mm on the left side before hydration. There was no statistically significant difference between right and left side renal length measurements. After hydration, the mean renal length was 113.5 ± 6.1 mm on the right side and 114.6 ± 6.6 mm on the left side. The mean increase in renal length after hydration was statistically significant (P < 0.001) and was 6.8% on the right side and 6.6% on the left side. Sex and age did not affect the measurements significantly.

Conclusions. Oral fluid intake causes a statistically significant increase in renal length. This observation should be taken into consideration when renal length measurements are clinically important.

Keywords: ultrasonography; kidneys; hydration; renal length; measurement

U-nilateral or bilateral reduction or increase in kidney size is an important sign of many renal diseases. Thus, knowledge of normal sonographic size is important when evaluating patients with renal diseases. Estimation of renal size via sonography can be performed by measuring renal length, renal volume, or cortical volume or thickness.1–5 Renal length and cortical thickness are routine measurements in the diagnosis and follow-up of most disease conditions involving the kidneys.6–9

In most institutions, sonographic evaluation of the genitourinary tract includes examination of the kidneys, ureter (if possible), and urinary bladder. Therefore, measurements regarding the kidneys, such as renal length, can be performed in a hydrated or nonhydrated state. Adequate hydration may be provided intravenously or via oral fluid intake,10,11 and is used primarily for accurate sonographic evaluation of the bladder. The diagnosis of various disease conditions of the urinary tract—such as obstruction or differentiation between a parapelvic cyst and hydronephrosis—requires adequate hydration.10–12 The effects of hydration on the renal pelvis have been widely studied10,12–14; however, the effect on renal length by means of sonography has not been established. The aim of our study was to evaluate whether oral fluid intake has an effect on renal length measurement.

MATERIALS AND METHODS

From October 2003 to September 2005, we prospectively measured kidney size in adult patients who were attending our ultrasound unit for reasons other than renal examinations. The inclu-
sion criterion for the study was normal appearance of the kidneys on sonographic examination. Exclusion criteria were chronic renal failure, hypertension, diabetes mellitus, chronic heart failure, history of hemodialysis or peritoneal dialysis, unilateral or partial nephrectomy, renal transplantation, any congenital anomaly in 1 or both of the kidneys, presence of a unilateral kidney, hydrenephrosis, renal cysts and/or neoplasms, renal calculi, and abnormal parenchymal echo appearance on initial examination. Written informed consent was obtained from all patients. The study was performed according to the guidelines of the Helsinki Declaration.

The study included 524 patients (group A, 291 male, 233 female) in which the examiner was not blinded to the hydration status or the renal length measurements. The mean age of the patients was 44 ± 12.3 years (range 17–76). An additional 100 patients (group B, 52 male, 48 female) were studied in which the examiner was both blinded to the hydration status and the renal length measurements. The mean age of these patients was 41 ± 14.8 years (range 18–71).

The examination was performed in a quite, temperature-controlled room (22°C) between 9 and 12 A.M. Real-time gray-scale sonography was performed with a 2–5-MHz convex transducer connected to a Sonoline Elegra scanner (Siemens Medical Solutions, Issaquah, WA). All the examinations were performed by a single experienced radiologist. Renal length measurements were performed for each kidney while patients were in the prone position. All measurements were performed in deep inspiration. Both renal poles were identified and the measurements were performed. At least 3 consecutive measurements were taken in the prone position for each kidney, and the mean of these measurements was calculated for each kidney.

Patients in group A were all hydrated, and the examinations were performed before and after hydration. All patients fasted the night before the examination and oral fluid intake was restricted for a minimum of 6 hours before the examination. For the first part of the study (baseline examination), the patients were asked to empty their bladder just before the sonographic examination. For the second part, the patients were subdivided into 2 groups. Group 1 patients (n = 50) consumed 1.5 l of water within 1 hour, while group 2 patients (n = 50) remained dehydrated. The second examination for group 1 patients (hydrated group) was performed when the patient noted bladder filling but no urgency. The second examination for group 2 patients (dehydrated group) was performed approximately 1.5 to 3 hours after the baseline examination. The timing was determined by an assistant who was blinded to the renal length measurements but not the hydration status. The physician who performed the examination was blinded to both the hydration status of the patients and the renal length measurements. Measurements were noted by an assistant who was also blinded to the hydration status of the patients.

SPSS software for Windows (version 7.5; SPSS Inc., Chicago, IL) was used for statistical analysis. The patients in group A were subgrouped based on side (right and left), gender (male and female), or age differences. Grouping based on age was made according to decades. Patients in subgroup 1 were less than 30 years old, subgroup 2 between 30 and 39 years, subgroup 3 between 40 and 49 years, subgroup 4 between 50 and 59 years, subgroup 5 between 60 and 69 years, and subgroup 6 older than 69 years. Statistical analysis included the overall comparison of the renal length measurements on each side (right and left) before and after hydration via paired-sample t-test. The comparison between gender groups and age groups was performed via independent-sample t-test. The changes among gender groups, side-to-side differences, and age groups between prehydration and posthydration measurements were

![Figure 1: Change in renal length (mm) before and after hydration.](image)
studied via analysis of variance. The patients in group B were assessed via paired-sample t-test for comparison of the baseline renal length measurements on each side (right and left) with the second measurements for group 1 and group 2 patients. The amount of change (percent) was calculated for both group 1 and group 2. A P value of less than 0.05 was considered statistically significant.

RESULTS

In group A, the mean renal length before hydration was 106.3 ± 5.6 mm on the right side and 107.5 ± 5.8 mm on the left side. Before hydration, there were no statistically significant differences between the right and left side renal length measurements (P > 0.05). After hydration, the mean renal lengths were 113.5 ± 6.1 mm and 114.6 ± 6.6 mm on the right and left sides, respectively. The mean increase in renal length was 6.8% and 6.6% on the right and left sides, respectively. After hydration, the comparison between the right and left renal length measurements was not statistically significant (P > 0.05). The renal length measurements before and after hydration on the right and left sides separately were statistically significant (P < 0.001) (Figures 1, 2). The renal length measurements were not statistically significant before or after hydration among males and females or among different age groups (Tables 1, 2). Analysis of variance revealed no significant effect of age, side, or gender on renal length measurements (P > 0.05).

In group B, the mean renal length at baseline examination was 101.7 ± 7.5 mm (right side, range 90.5–118.9 mm) and 102.3 ± 6.9 mm (left side, range 91.2–119.7 mm) for the patients who were hydrated (group 1), and 102.6 ± 9.5 mm (right side, range 90.4–119.2 mm) and 103.1 ± 9.8 mm (left side, range 90.1–121.1 mm) for patients who remained dehydrated (group 2). The mean renal length after hydration was 107.4 ± 8.1 mm (right side, range 91.1–123.4 mm) and 108.2 ± 7.2 mm (left side, range 95.1–122.8 mm) for patients in group 1. The second examination for group 2 revealed a mean renal length of 102.8 ± 9.7 mm (right side, range 90.6–120.6 mm) and 103.2 ± 9.7 mm (left side, range 90–120.7 mm). The statistical analysis revealed a significant change in group 1 (P < 0.001), while there was no statistically significant change in group 2 (P = 0.164 for right side, P = 0.251 for left side). The mean re-
nal length increased 5.6% (right side) and 5.8% (left side) in group 1. The change was 0.1% (right and left sides) increase for group 2.

**DISCUSSION**

Sonographic evaluation of the kidney is generally a part of the urinary tract examination, in which the kidneys, ureter, and bladder are evaluated. The kidneys may be well identified in a nonfasting patient; however, fasting may be desired to limit bowel gas. When the kidneys are part of a full urinary tract examination (ie, kidneys, ureter, and bladder), high fluid intake is commonly used to accelerate urine production. The examination is performed by filling the bladder with a moderate amount of urine. Therefore, it is essential to know the effects of fluid intake on renal physiology and the morphological changes associated with it. The hydration status of the patients by way of oral fluid intake varies from patient to patient. Assessing the hydration status is a complex issue and can be accomplished by measuring body weight, hemoglobin and hematocrit levels, serum osmolality, sodium concentration, and urine-specific gravity and osmolality and via bioelectrical impedance analysis. In our study, although the patients consumed 1.5 l of water, a standardized hydration status was not achieved and should be noted as a limitation of the study. Therefore, we attributed changes in renal length on sonographic examination to changes in fluid intake and excretion on the part of the patient.

Although the renal effects of hydration are not well defined, it is said that hydration lowers the glomerular filtration rate (GFR) and increases the natriuresis. Increase in natriuresis after oral fluid intake may manifest as mild or moderate hydronephrosis, a common observation during routine sonographic examination of the kidneys. We cannot directly examine the histopathological changes in the kidneys after fluid intake, and we do not know what changes occur in the glomerulus and collecting tubules in this situation. On the other hand, the gross morphological changes may be studied with imaging modalities such as sonography, CT, or MRI. We hypothesized that the increased amount of urine production caused by oral fluid intake probably distended the collecting ducts, and this in turn may manifest as an increase in the dimension of the kidneys.

The position of the patient is probably one of the most important aspects of sonographic examination of the kidneys. The kidneys are ovoid on cross-section, with the largest dimension proceeding anteromedially to posteromedially. Therefore, longitudinal views of the kidney will demonstrate a different shape depending on how the view was obtained. For this reason, we examined patients in the prone position. A posterior approach allows the transducer to be closer to the kidneys, and the measurement technique is more standardized.

There is little information available regarding the accuracy of sonography in the evaluation of renal size. Renal volume measurements calculated with the ellipsoid formula applied to sonographic images can result in a considerable systematic underestimation of renal volume and have large intra-observer and interobserver variations. On the other hand, it has been suggested that renal length measurements are more reliable than volume measurements.
measurements. Ablett et al\textsuperscript{22} studied interobserver and intraobserver variations in renal length measurements and found that the magnitude of variation is similar whether the left or right kidney is measured and whether measurements are made by 1 or multiple sonographers. They reported that the SDs ranged between 4.8 and 7.2 mm. Emamian et al\textsuperscript{1} found a relative SD of 4\%–5\% for renal length in adults. In our study, in which the examiner was blinded to both the hydration status and renal length measurements, no statistically significant change in renal length measurements were found in patients who were not hydrated. On the other hand, an approximately 6\% increase was seen in patients who were hydrated in the blinded study group. In the nonblinded group in which all the patients were hydrated, the change was approximately 7\%. However, in the studies by Ablett et al\textsuperscript{22} and Emamian et al,\textsuperscript{1} the hydration status of the patients was not standardized. The great interobserver and intraobserver difference may be due to the hydration status of the patients. For practical reasons, it was not possible at the beginning of our study to create a blinded study design. Therefore, we conducted a satellite-blinded study design in a new but smaller group of patients due to the significant bias introduced by a nonblinded study. Our results in the blinded study group confirmed the change in renal length measurements (6\% for the blinded group, 7\% for the nonblinded group), which was probably caused by the hydration of the patients.

A reduction in renal length is considered an indicator of chronic renal disease, with a value of 9 cm or less indicating irreversible disease.\textsuperscript{23} It may also be used in follow-up for the progression of a disease process affecting the kidneys; therefore, accurate renal length measurements are important.\textsuperscript{6–9} In our study, we found an approximately 7\% increase in renal length measurements after oral fluid intake. Based on our results, one may estimate that renal length measurements are prone to variability depending on the fluid intake of the patient. An important aspect of renal sonographic examination is sequential imaging change in which the enlargement or reduction of the kidney is associated with a disease pattern. We believe that in such a situation, the patients are their own control with the awareness that the same level of fluid intake should be present when sequential sonograms are obtained. Our study included patients without renal complaints and sonographically normal kidneys; however, the effect of hydration on renal length in abnormal or diseased kidneys is not known. This issue should be investigated further.

In conclusion, it is essential to understand that renal length measurements may change after oral fluid intake. This fact should be kept in mind for disease processes in which renal length measurements are clinically important and are used in the follow-up.

REFERENCES