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Sonographic measurement of renal length in children: does the position of the patient matter?

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Abstract *Purpose.* This prospective study was designed to determine the effect of patient positioning on sonographic measurements of renal length in children.
Materials and methods. Two dedicated pediatric ultrasonographers (observers A and B) measured the sonographic lengths of 48 kidneys in 25 children (two had unilateral renal agenesis). Each observer obtained the two "longest possible" measurements for each kidney with the patient in three positions: supine, contralateral decubitus, and prone. Patients with myelomeningocele, hydronephrosis, and renal cysts were excluded.
Results. Both examiners obtained significantly higher values for renal lengths with the children lying supine (observer A $P \leq 0.0017$; observer B $P \leq 0.0409$) or in contralateral decubitus (observer A $P \leq 0.0001$; observer B $P \leq 0.0419$) than with them lying prone. There was no significant difference between the supine and decubitus measurements. The mean difference between the supine and prone measurements for the observers was 3.0 mm for observer A and 1.8 mm for observer B. The mean difference between the contralateral decubitus and prone measurements was 3.0 mm for observer A and 1.6 mm for observer B.
Conclusion. Sonographic measurements of renal length made with the patient lying supine or in contralateral decubitus yield slightly higher values than those made with the patient prone.

Introduction

The purpose of this study was to assess prospectively the effect of patient position on the reproducibility of measurements of renal length obtained during ultrasonography.

Materials and methods

During a 1-month period, 25 children (11 boys and 14 girls) with 48 kidneys (two had solitary kidneys) were enrolled. The children ranged in age from 0.05 to 17.54 years (mean 9.06 years). Children with myelomeningocele, scoliosis, ectopic or horseshoe kidney, hydronephrosis, or renal cysts were excluded because these abnormalities might affect the reproducibility of the measurements of renal length. Two experienced pediatric ultrasonography technologists performed all of the examinations. Each measured the maximum length of each kidney in each patient six times: twice with the patient lying supine, twice with the patient prone, and twice with the patient lying with the contralateral side down. The measurements were made on a freeze-frame image during the real-time examination with electronic calipers using Acuson 128 ultrasound imaging systems (Mountain View, Calif.) with 3.5-, 5.0-, or 7.5-MHz sector transducers. In each patient, the same probe was used by both technologists. The technologists were blinded to each other's measurements.

Intra-observer variation was assessed by comparing the two measurements made by each examiner in each patient position. Inter-observer variation was assessed by comparing the average of the two renal lengths obtained by each examiner in each of the three patient positions. The data were analyzed descriptively and with a two-tailed *t*-test.

Table 1 Intra-observer variations in measurements of longest renal length (in mm) made with the patients in different positions (supine, prone, and contralateral decubitus)

	Observer A			Observer B		
	(A1–A2)[a]		(A1+A2)/2[b] Mean	(B1–B2)[a]		(B1+B2)/2[b] Mean
	Mean	Range		Mean	Range	
Supine	3.4	0–13.2	91.8	2.9	0–11.4	88.8
Decubitus	2.9	0.1–12.3	92.1	1.8	0–7.7	89.1
Prone	2.2	0–7.8	89.4	1.7	0–7.9	87.5

[a] Absolute value of the difference between the two measurements of each renal length
[b] Average of the two repeated measurements of each renal length

Table 2 Inter-observer variation in measurements of longest renal length (mm) made by two technologists with the patients supine, prone, and in contralateral decubitus

	Mean renal length[a]		Difference (A–B)[b]		
	Observer A	Observer B	Mean	Range	*P*
Supine vs prone	93.5	90.2	3.3	–18.2 to 13.8	$\leq$ 0.0006
Supine vs decubitus	93.3	89.7	3.6	–5.3 to 15.3	$\leq$ 0.0001
Decubitus vs prone	92.7	89.5	3.1	–6.4 to 14.7	$\leq$ 0.0007

[a] Average of the two measurements made for each kidney by each observer in the three positions
[b] Difference between the averages of the two measurements made for each kidney by each observer in each of the three positions

Table 3 Positional variations in measurements of longest renal length (in mm) made with the patients in different positions (supine, prone, and contralateral decubitus)

	Mean difference[a]	Range	*P*
Supine vs decubitus	–0.3	–8.6 to 4.5	NS
Supine vs prone	1.8	–9.1 to 19.2	$\leq$ 0.014
Decubitus vs prone	2.1	–6.5 to 17.3	$\leq$ 0.002

[a] Mean of the differences between the averages of the four measurements of each renal length made by the two observers in each position

Results

Intra-observer and inter-observer variations in the measurements of renal length are summarized in Tables 1 and 2. Intra-observer variation was greatest for the supine measurements (3.4 mm for observer A, 2.9 mm for observer B) and least for the prone measurements (2.2 mm for observer A, 1.7 mm for observer B). Although observer A consistently obtained slightly longer measurements of renal length than observer B, the variation in observer A's measurements was also slightly greater. The mean difference between the measurements made by the two examiners was similar in the three positions (3.1–3.6 mm).

The variations in the measurements of renal length with the patients in the different positions are summarized in Table 3. The values obtained for renal length with the patients lying prone were significantly lower than those obtained with the patients lying either supine ($P \leq 0.014$) or on their sides ($P \leq 0.002$). There was no significant difference in renal length between the supine and the contralateral decubitus positions.

Discussion

Measurements of kidney length and comparison of these measurements with normal standards are fundamental aspects of the sonographic examination of the upper urinary tract in children [1–5]. Comparison of measurements obtained over the course of sequential examinations permits assessment of renal growth over time [1, 6–8]. In order for such comparisons to be useful, the measurements themselves must be both accurate and reproducible [1]. Unfortunately, the accuracy and reproducibility of both urographic [9–12] and sonographic [13–15] measurements of renal length are influenced by many factors, some inherent in the patient, others in the examiner or in the equipment used.

Factors inherent in the patient include those that interfere with the direct interrogation of the kidneys from a standard trajectory [1, 13]. Interference by distended gas-filled loops of bowel, interposed scars, dressings, or tubes is common. In patients with kyphoscoliosis, as in those with ectopic kidneys, changes in both position and inclination of the kidneys in the retroperitoneum can both alter the measurements of kidney length and reduce their reproducibility [1, 16]. If the entire length of the kidney cannot be included in the field of view, as in children with very large or superficially located kidneys, accurate measurements may not be obtainable [14]. Excessive patient motion, e.g. in frightened children, can also limit the reliability of the measurements. Al-

though such problems are generally beyond the control of the examiner, recognition that the examination is suboptimal is important to avoid overreliance on inaccurate measurements [1].

Observer-related variations in the measurements are also significant. Schlesinger et al. [15] evaluated the variations in repeated measurements of renal length by three experienced pediatric sonographers. They showed that both intra- and inter-observer variations in the measurements can equal or even exceed the expected annual rate of growth in older infants and children. The mean inter- and intra-observer variations in their study were 3.9–5.5 mm and 0.9–3.6 mm, respectively. In our study, the mean inter-observer variation was 3.1–3.6 mm depending on patient position (Table 2). The mean intra-observer variation was 1.7–2.9 mm (Table 1). The mean difference in renal length in various positions was −0.3 to 2.1 mm (Table 3).

The influence of patient positioning on measurements of renal length has important implications for the application of sonographic renal growth charts in infants and children. The standards published by Dinkel et al. [3] were based on measurements made with patients lying prone with a pillow beneath the abdomen to decrease the lumbar lordosis. Blane et al. [2] and Rosenbaum et al. [5], on the other hand, obtained measurements with patients lying supine. Our demonstration of positional variation in the measurements suggests that clinical application of such standards would be most reliable if the method used for measuring renal length in the study population were reproduced as closely as possible in the clinical setting. Similarly, in patients who present for follow-up examinations, the reliability of comparison with previous measurements can be increased by consistently examining patients in the same position.

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