Sonographic Assessment of Renal Length in Normal Children

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Renal length was measured from normal real-time sonograms of 203 pediatric patients and graphed to provide a "growth chart" of normal renal size vs. age. Mean renal lengths are reported for each year of age. For children older than 1 year, the regression equation is: renal length (cm) = 6.79 + 0.22 × age (years). For babies younger than 1 year, the equation is: renal length (cm) = 4.98 + 0.155 × age (months).

Sonography is now being used in the initial evaluation of children with symptoms and signs referable to the urinary tract. Radiographic evaluation of kidneys, in our department, includes measurement of renal length and its comparison to a "growth chart" of normals [1, 2]. In order to have a similar chart for use in sonography, renal length vs. age was plotted in 203 children who had real-time sonography.

Materials and Methods

Sonography was performed on 203 children with a real-time mechanical sector scanner, either a Diasonics Wide-vue using a 3.5, 5, or 7.5 MHz transducer or a Diasonics Neonatal Unit using a 6 MHz transducer. Indications for study included: urinary tract infection (77 patients), "screening" (77 patients with abnormal urinalysis, enuresis, aniridia, scoliosis, undescended testicle, or other problems), spinal abnormality (18), abdominal pain (13), question of sepsis (six), question of mass (four), gastrointestinal abnormality (four), and hypertension (four). Patients were excluded from consideration if they had a history of malignancy, use of steroids, upper urinary tract abnormality, vesicoureteric reflux (greater than grade 1), or urologic surgery, or if the sonography of the kidneys was considered abnormal (e.g., hydronephrosis, dysplastic kidney, solitary kidney). Recognized duplex kidneys were also excluded.

The ultrasonic transducer was positioned to image the kidney in its longest dimension (fig. 1), and the renal lengths reported here were measured with mechanical calipers from the hard-copy transparencies exposed at the time of study.

The patients' ages were recorded to the closest month for those older than 1 year and to the closest week for those younger than 1 year. Weight, height, and body surface area were not recorded for all patients and could not be used for statistical analysis.

Results

The 203 patients ranged in age from several hours to 19 years; figure 2 shows the distribution of patients' ages. Length was measured in 406 kidneys; mean renal lengths are presented in table 1 and are plotted in figure 3.

For more detailed analysis, the population was divided into two groups: children less than 1 year old and children 1 year or older. These groups were chosen because of the more rapid change in kidney size during the first year of life (fig. 3). For the younger group, the following regression equation was obtained: length (cm) = 4.98 + 0.155 × age (months) (t_{90} = 6.86, $p < 0.001$; SD = 0.69; r^2 = 0.3437). For the population aged 1 year or older: length (cm) = 6.79 + 0.22 × age (years)

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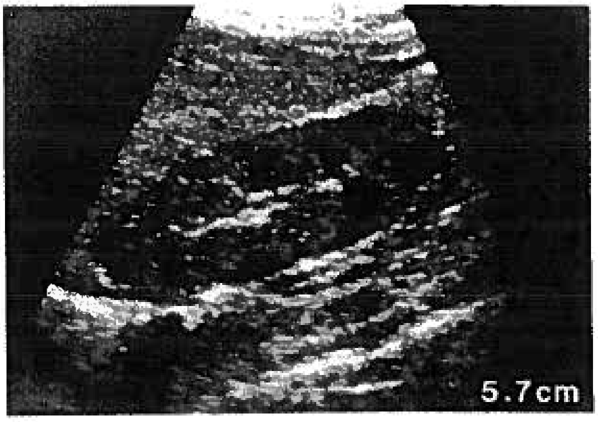

Fig. 1.—Length of kidney can be measured with electronic calipers, as on this image of right kidney in 5-month-old baby. For purpose of this study, measurements were done with mechanical calipers.

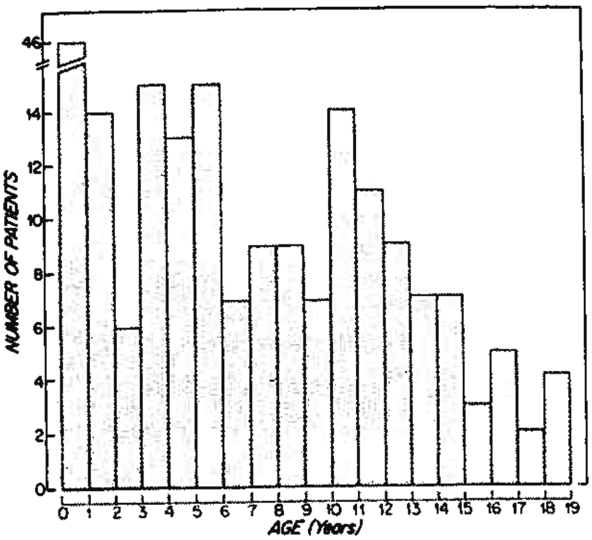

Fig. 2.—Distribution of patients' ages.

TABLE 1: **Summary of Grouped Observations—Mean Renal Length**

Average Age*	Interval*	Mean Renal Length (cm)	SD	*n*
0 mo	0–1 wk	4.48	0.31	10
2 mo	1 wk–4 mo	5.28	.66	54
6 mo	4–8 mo	6.15	.67	20
10 mo	8 mo–1 yr	6.23	.63	8
1½	1–2	6.65	.54	28
2½	2–3	7.36	.54	12
3½	3–4	7.36	.64	30
4½	4–5	7.87	.50	26
5½	5–6	8.09	.54	30
6½	6–7	7.83	.72	14
7½	7–8	8.33	.51	18
8½	8–9	8.90	.88	18
9½	9–10	9.20	.90	14
10½	10–11	9.17	.82	28
11½	11–12	9.60	.64	22
12½	12–13	10.42	.87	18
13½	13–14	9.79	.75	14
14½	14–15	10.05	.62	14
15½	15–16	10.93	.76	6
16½	16–17	10.04	.86	10
17½	17–18	10.53	.29	4
18½	18–19	10.81	1.13	8

* Years unless specified otherwise.

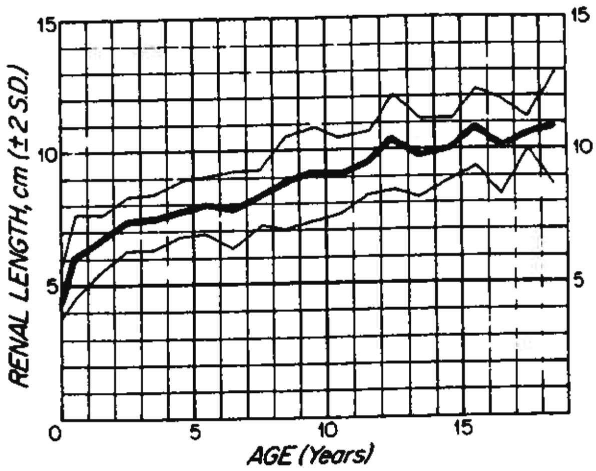

Fig. 3.—Sonographic renal length plotted against age.

(t_{326} = 28, $p < 0.001$; SD = 0.79; r^2 = 0.7077). On the average, the left kidney was 1.9 mm longer than the right, but this finding is of no significance in an individual instance.

Discussion

In 1962, Hodson et al. [3] reported the renal size of 393 children based on excretory urography and presented a graph of renal length vs. age. Others [4, 5] reported findings that superimposed on the graph of Hodson et al., and the usefulness and limitations of such growth charts have been discussed [1, 2, 6, 7]. However, the radiographic technique itself yields some variability in the apparent size of the kidney due to differences in centering of the tube and its distance from the patient, phase of respiration, and osmotic effects of the iodinated contrast material [7–9]. Sonography allows measurements that are not subject to the above variables and furthermore provides such information without exposing the patient to ionizing radiation.

The potential of renal sonography in children was outlined by Lyons et al. in 1972 [10] and was expanded by subsequent reports [11, 12]. Sonographic measurement (B-mode) of renal length in 30 children was reported by Tay et al. in 1977 [13], but the data were compared only to excretory urography data, without mention of whether the studies were normal or not, and no renal length/patient age comparison was made.

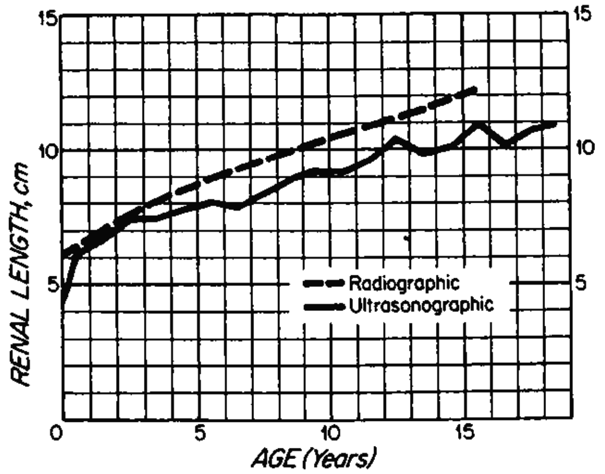

Fig. 4.—Sonographic renal length compared with radiographic renal length [5] as function of age.

Haugstvedt and Lundberg [14] reported renal size in 46 normal children by articulated-arm sonography. Their data, which were grouped into larger age categories, seem comparable to what we obtained with real-time scanning. More recently, Peters et al. [15] reported on 233 infants, but their data are presented as a calculated renal volume compared with body weight (range, 2–11 kg) and are thus difficult to compare with our findings.

We chose to compare renal length with age because it is the easiest, most practical approach. Many authors mentioned above have discussed some aspect of the relation of renal size (weight, area, length, width, and/or volume) to factors of body size such as weight, height, body surface area, and age. The general conclusion that the radiographic measurement of renal length is the most practical is reached by many [1, 3, 6–8], and it can most easily be related to patient age, although perhaps more accurately to a segment of lumbar spine included on the radiograph [4–6]. We have found the sonographic "renal length vs. patient age" graph useful as a screening tool in patients specifically referred for renal sonography as well as in those whose kidneys are incidentally imaged, for example as part of a study of liver or gallbladder. Because there are no easily determined "internal standards" to which to relate sonographic renal dimensions (such as lumbar vertebrae in the case of radiography), such a chart is necessary. Beyond screening, more detailed sonographic assessment of renal size may be done using methods by which renal mass and/or volume can be determined [15–18].

One potential drawback of articulated-arm scanning is that length may be underestimated by failure to image the kidney in its greatest dimension. This is less likely to happen with the more maneuverable real-time transducer, but meticulous scanning is necessary with either method. Sometimes the entire kidney of an older child extends outside the sector of a real-time scanner, leading to an estimation of renal size by extrapolation. This can be avoided by the use of a water bath between the transducer and skin to create a wider arc of view, or by using an articulated-arm scanner.

We compared the graph of mean renal length by sonography (fig. 3) with the one that we use for the radiographic assessment of renal length [1]; these graphs are superimposed in figure 4. We assume that the jaggedness of the sonography curve, especially beyond 10 years, is due to relatively smaller sample size of older children (table 1). The greater renal size by radiography is expected from magnification, and an apparent divergence of the curves in the older children is in keeping with a greater magnification in the older, larger patients. We expect that as more patients are included in this study, the curve will smooth out and the standard deviations will stabilize.

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