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Renal Parenchymal Thickness in Children Measured by Computed Tomography

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Key Words
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Abstract
Renal parenchymal thickness was measured at different regions and levels through the kidney in 162 abdominal computed tomography (CT) examinations of children 5 months to 14 years old. The transverse diameter of the first lumbar vertebra (L_1) was also measured, in order to take into account the child's body habitus. All patients were examined with an indication other than renal disease and had no abnormal CT findings in the retroperitoneum. Renal parenchyma increased in parallel with the transverse diameter of L_1 and did not depend on age or sex in children of the same body format. There were no significant differences in size between the right and the left kidneys. Renal measurements were tabulated on reference tables, as an aid in the assessment of renal parenchymal thickness in children undergoing abdominal CT examination.

Introduction

The size of the normal kidney has been adequately studied in children by means of ultrasonography and intravenous urography [1–4]. Kidney length and area measurements are useful in the interpretation of renal images but, in the evaluation of renal damage in children with vesico-ureteric reflux, measurements of parenchymal thickness at urography are more reliable [5–8]. Computed tomography (CT) is the most accurate means of measuring parenchymal thickness at different regions of the kidney and estimating changes in the amount of renal parenchyma [9]. To our knowledge, CT measurements of the normal kidney in children have not been previously reported.

In this study, multiple measurements of normal renal parenchymal thickness were performed by CT, and the amount of renal parenchyma was related to the child's age, sex and body habitus. These measurements are given on reference tables, as an aid in the evaluation of renal parenchyma on CT.

Material and Methods

The study comprised 162 non-contrast-enhanced CT examinations of 95 boys and 67 girls, 5 months to 14 years old. All patients underwent abdominal CT examination with no indication of kidney disease and had no abnormal CT findings in the retroperitoneum. Children with a history of renal disease, congenital malformation of the kidneys or any other cause that may alter kidney morphology were not included in this study.

Renal measurements were obtained from sections that were part of the routine abdominal CT examination, with a slice thickness of 10 mm for older and 5 or 10 mm for younger children. No patient underwent additional scans for the purpose of this work. Renal parenchymal thickness was measured on three CT sections selected from each kidney. One section was through the renal pelvis and two through the upper and lower calyceal levels at the maximum diame-

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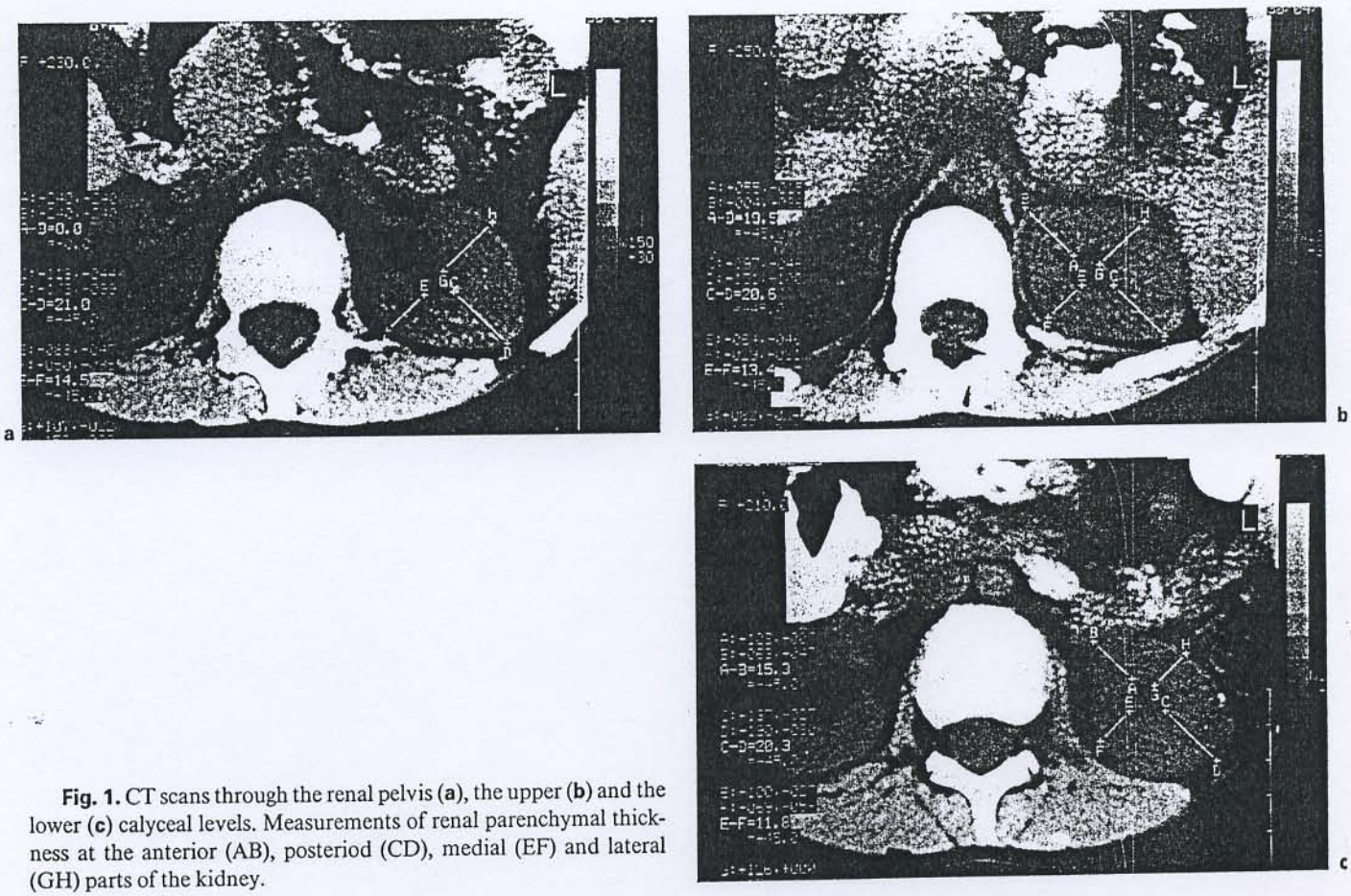

Fig. 1. CT scans through the renal pelvis (**a**), the upper (**b**) and the lower (**c**) calyceal levels. Measurements of renal parenchymal thickness at the anterior (AB), posteriod (CD), medial (EF) and lateral (GH) parts of the kidney.

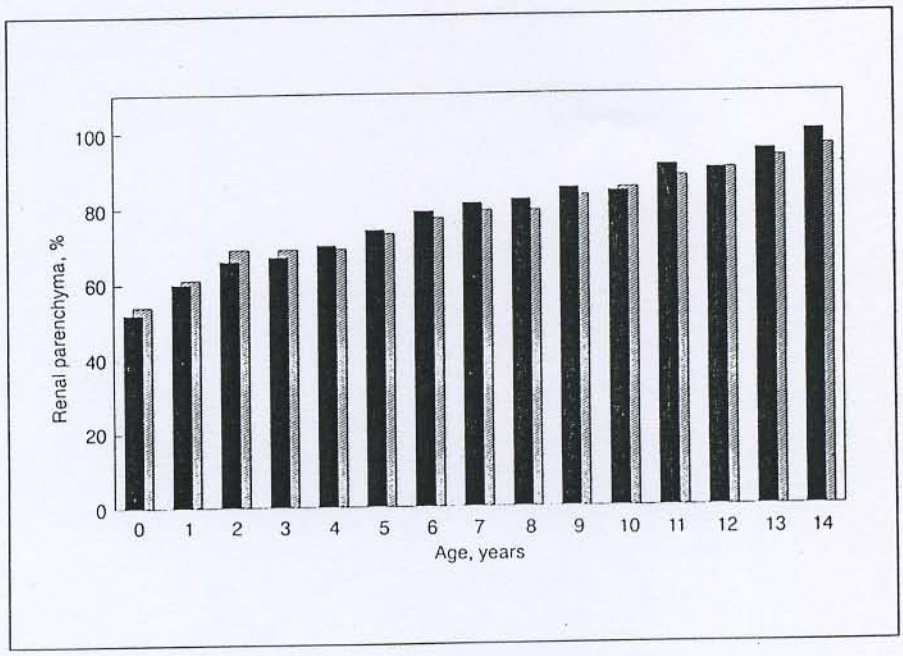

Fig. 2. Renal parenchymal growth during childhood for the left (■) and right (▨) kidneys.

Table 1. Renal parenchymal thickness and L_1 diameter during childhood (means ± SD)

Age years	Patients	S(a + b + c + d), mm		DL_1, mm		S(a + b + c + d)/DL_1	
		boys	girls	boys	girls	boys	girls
0–1	9	130±14	126±12	21±2	21±2	6.19±0.55	6.00±0.50
1–2	7	159±12	142±14	26±2	25±3	6.12±0.51	5.68±0.69
2–3	7	160±18	149±10	27±3	25±2	5.93±0.49	5.96±0.56
3–4	14	165±14	169±15	27±3	26±3	6.11±0.54	6.50±0.49
4–5	10	179±20	157±18	28±4	27±2	6.39±0.66	5.81±0.41
5–6	15	178±19	178±12	29±4	29±3	6.17±0.38	6.17±0.67
6–7	12	193±13	185±14	33±3	29±3	5.88±0.39	6.38±0.56
7–8	9	202±16	186±19	34±3	30±4	5.94±0.50	6.20±0.57
8–9	8	192±17	189±15	34±5	33±4	5.65±0.72	5.73±0.55
9–10	9	207±15	196±18	35±5	33±4	5.91±0.69	5.94±0.61
10–11	12	202±18	208±20	37±4	35±4	5.46±0.63	5.94±0.44
11–12	13	227±18	205±18	37±5	35±5	6.14±0.57	5.86±0.49
12–13	10	218±19	217±20	38±4	36±5	5.74±0.58	6.03±0.61
13–14	12	229±19	223±19	39±5	36±4	5.87±0.68	6.19±0.69
14–15	15	246±22	227±18	40±5	36±5	6.15±0.67	6.31±0.49

S(a + b + c + d) = The overall sum per kidney of the anterior (a), posterior (b), medial (c) and lateral (d) parenchymal thickness measurements at 3 selected levels through the kidney; DL_1 = transverse diameter of L_1.

ter of the calyces. Measurements at the renal pelvis were obtained by means of two perpendicular axes, one being along the renal vessels. Parallel sets of similar axes were also employed at the upper and lower calyceal levels. Parenchymal thickness measurements of the anterior (a), posterior (b), medial (c) and lateral (d) parts of the kidney were performed, a total of 11 measurements per kidney (fig. 1). The sum of these measurements was used as indicative of the amount of renal parenchyma.

All renal measurements were also divided by the transverse diameter of the first lumbar vertebra (L_1), obtained at the middle of the vertebral body, in order to take into account the patient's body habitus [9, 10]. The total sum of these 11 ratios – 'the normalized kidney size' was used to examine the influence of age and sex in the amount of renal parenchyma.

Data were analysed on a computer employing Student's t test and the paired t test, in order to examine differences between the two sexes and the right and left kidneys, respectively. The parametric regression analysis was used to correlate the amount of renal parenchyma with age and the L_1 diameter.

Table 2. Representative ratios of renal parenchymal thickness in children (means ± SD)

	Upper calyceal level	Middle level	Lower calyceal level
a/DL_1	0.61±0.04	–	0.49±0.05
b/DL_1	0.73±0.07	0.78±0.08	0.70±0.06
c/DL_1	0.46±0.05	0.50±0.05	0.44±0.05
d/DL_1	0.50±0.05	0.51±0.05	0.45±0.04

a, b, c, d = Anterior, posterior, medial and lateral parts of the kidney, respectively; DL_1 = transverse diameter of L_1.

Results

Renal growth during childhood is shown in figure 2. Data analysis revealed that the amount of renal parenchyma does not differ significantly between the kidneys of the same patient ($p > 0.10$). Thus, no further discrimination was made between the right and left kidneys. Measurements of renal parenchyma and L_1 diameter during childhood are shown in table 1. A strong correlation was found between the amount of renal parenchyma and the transverse diameter of the first lumbar vertebra (boys: $r = 0.969$, $p < 0.001$, girls: $r = 0.971$, $p < 0.001$).

None of the 11 ratios – parenchymal thickness measurements divided by the L_1 diameter (table 2) – was found to vary significantly with age ($-0.301 < r < +0.202$, $p > 0.10$). Also, the normalized kidney size remained relatively constant during childhood (boys: $r = -0.201$, $p > 0.10$, girls: $r = 0.108$, $p > 0.10$). There were no significant differences in the normalized kidney size between boys and girls ($p > 0.10$), when the body habitus was taken into account.

Discussion

Several studies have estimated the size of the normal kidney in children on sonograms or urographic films [1–4]. At ultrasonography, measurements could not be referred to an obvious 'internal' standard [1], and no distinction was made between the functional renal parenchyma and the peripelvic fat or the calyces. At urography, measurements were obtained from children with suspected renal disease [4]. In this study, data were selected from children undergoing abdominal CT examination with no evidence of renal disease. Also, renal parenchyma could be adequately delineated by CT at different regions and levels through the kidney.

The present study showed that the right and the left kidney had approximately the same amount of renal parenchyma. Previous studies have expressed conflicting views, but most authors [2, 4, 10] have found no size differences between the two kidneys. According to the findings of this study renal growth during childhood was proportional to the increase in diameter of the first lumbar vertebra. This is in agreement with the findings of other workers [4, 10] that the length of the kidney at urography is strongly related to the L_1–L_3 distance of the lumbar segment. The results of this study suggested that, for a given diameter of L_1, the renal parenchyma did not differ between boys and girls or between children of different ages. Thus, differences in the amount of renal parenchyma observed between older and younger children or between males and females were due to variations in body format and not because of age or sex differences. Additionally, it was found that the normalized kidney size did not vary during childhood, while it has been shown [9] that in adults it decreases with advancing age.

Infection of the kidney in cases of vesico-ureteric reflux may induce damage to the renal parenchyma, which is radiologically depicted as scarring or areas of parenchymal thinning [6, 7]. The progression of existing scars or thinned areas and the development of new ones are the most important radiological parameters in the evaluation of the treatment of vesico-ureteric reflux [7]. Another significant sign of renal infection, with or without vesico-ureteric reflux, is growth retardation of the kidney [5, 8]. All these types of renal damage have been previously evaluated by measurements of renal parenchymal thickness on urograms [5–8]. However, these measurements can be obtained at urography only at the two renal poles and the lateral zone of the kidney, and, thus, changes in parenchymal thickness at other regions may be missed. This should be taken into consideration, since the number and extent of thinned areas and the early detection of new ones influence the management of children treated for vesico-ureteric reflux [11]. On the other hand, CT can perform multiple measurements of renal parenchymal thickness at different regions and levels through the kidney. In this study, 11 parenchymal thickness measurements were obtained from each kidney. These measurements, normalized to the L_1 diameter, were found to be relatively constant during childhood and may be employed in everyday practice in the assessment of renal parenchymal thickness in children undergoing abdominal CT.

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