ORIGINAL ARTICLE

Radiological Assessment of Renal Length in Children

by

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Abstract

Assessment of kidney length to other easily available parameters such as L1–L3 length and age in the evaluation and care of growing children with kidney disease is a prerequisite. Eighty nine IVP photos were selected from children with urinary tract infection. Radiological examinations were done after the absence of clinical and laboratory abnormalities. Nine or 10.1% IVP photos had radiological abnormalities so they were excluded from this study. There was no difference in kidney length between boys and girls. There was a difference in length between the right and the left kidney. A strong correlation was found between kidney length and L1–L3 length, age, body height and body weight. Tables are presented for charting data on kidney length and will be of use by pediatricians, radiologists and urologists in the care of growing children with kidney ailments.

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Introduction

Assessment of kidney size by radiological means is an important consideration in the diagnosis, prognosis, course and treatment of renal diseases (Friedenberg et al., 1965). Serial determinations of renal size on intravenous pyelography (IVP) in growing child are useful indicators of structural and functional abnormalities of the kidneys (Hernandez et al., 1979).

Morphologically, in majority renal diseases are manifest by some structural change in the size or shape of the kidney. It either enlarges or diminishes in size as a whole or a part. Hodson (1972) had succeeded in defining various causes of a small or a large kidney. Serial IVP are of proven value in following children with vesico-ureteral reflux. Normally the growing kidney is a healthy kidney, and the efficacy of treatment if children with vesico-ureteral reflux can be monitored by assessing the renal growth rate (International Reflux Study Committee, 1981). The usefulness of serial IVP examinations has provided a means of studying the natural history of certain renal diseases. A number of renal conditions which firstly attract attention to themselves in adult life have in fact been present since childhood (Hodson et al., 1962). Examples are chronic pyelonephritis, certain types of ischaemic kidney and chronic glomerulonephritis. The effect of reflux on renal function has generally been evaluated by following the changes in renal parenchym. Aperia et al. (1977) in their study confirmed the previous radiological impression that renal function decline progressively with the reduction of renal size.

Conflict exists how renal size is best estimated from radiographs. Different methods for estimating the kidney size has been reported (Currarino, 1965; Friedenberg et al., 1965; Ludin, 1967; Hegedus, 1972; Griffith et al., 1974; Aperia et al., 1977). Determination of renal length on the IVP is helpful because it correlates well with the true kidney weight (Ludin, 1967; Griffith et al., 1974) and it is one of the simplest and most direct method of estimating the kidney size by measurement made on anteroposterior roentgenogram of the abdomen (Friedenberg et al., 1965; Eklof and Ringertz, 1976). Assessing kidney size in adults, is by the use of the length as the single guideline (Moell, 1956; Eklof and Ringertz, 1976). In the growing child, however, correlation of kidney length to another easily available parameter (age, body height, weight and L1–L3 lenght) is a prerequisite for a meaningful evaluation.

Practicall application of this information requires knowledge of the range in length of normal kidneys. The purpose of this paper is to report the kidney length in 80 patients in the Department of Childhealth, School of Medicine, University of Indonesia in Jakarta, population with no recognizable clinical, laboratory and radiological renal abnormalities. The kidney length was measured on abdominal roentgenogram obtained during IVP and it's correlation with the distance L1–L3, age, body height and body weight. Emphasis was given to differences of the kidney length between sex and between right and left kidney.

Materials and Methods

Eighty nine IVP photos of four minutes were collected between December 1986 and January 1989. The indication performing the IVP was urinary tract infection. IVP photos with other indications were not included in this study.

All IVP were made after disappearance of the clinical and laboratory abnormalities. To obtain maximum diagnostic information, an adequate bowel preparation before urinary tract investigation was done on every patient. IVP photos were made with a Siemnens X-Ray unit and a 100 cm target film distance. The exposures were made in the same phase (expiration) when it was possible and the children were well hydrated before examinations. A standard dose of 2 cc/kg body weight with a maximum of 20 cc of 76% urografin was used.

Nine IVP photos were discarded at the initial radiological examination. Two cases had small kidneys, four cases each had hydronephrosis. The remaining three showed renal scarring, calcification of a kidney and a vesicolith. The four minutes IVP photo was next studied for the upper and lower margin of the kidney. On all eighty IVP photos of 4 minutes the upper and the lower margin of the kidney were clearly visible on both sides and it could be mesured. Measurement were made at two different times apart. Both sides kidney and the L1–L3 length were measured with a 20 cm ruler. The same ruler was used for all measurements. The procedure of measurement appears in Figure 1. No correction was made for magnification.

Figure 1 : *Supine photo exposed on 4 minutes urography, demonstrating technique of measurement.*

Statistical analysis was performed on a casio fx- 1000F and a personal computer. ''T'' test was applied to determine any influence on measurement of renal length by sex and kidney position namely left or right kidney. Correlation analysis between kidney length with L1–L3 length, age, body height and body weight was performed. The level of significance in this study is 0.01. Tables of kidney length in relation with the distance of L1–L3 and age were presented.

Results

There were 80 IVP photos of patients with ages ranging from 5 months to 14 years old. Two of the 9 patients under 1 year were below six months and 2 patients were above 12 years old (Figure 2).

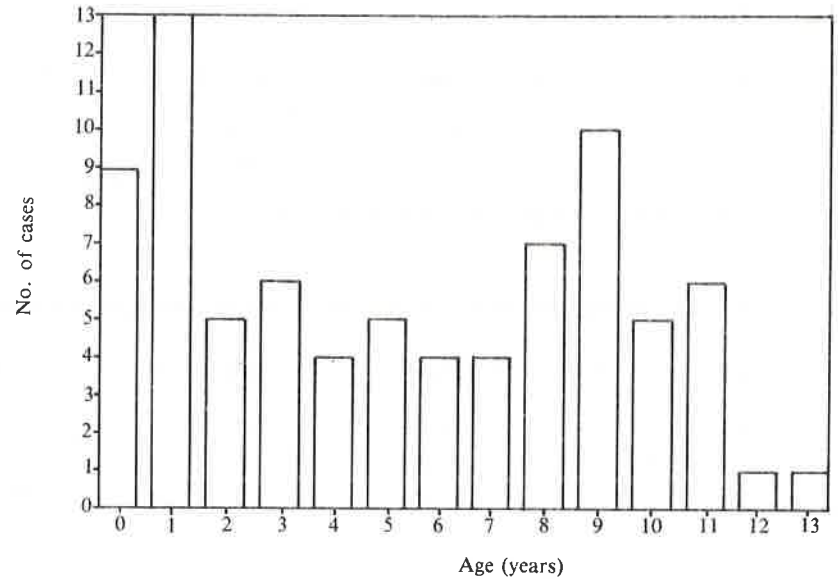

Figure 2 : *Bargraph of 80 cases-age*

There were 47 boys and 33 girls (Table 1).

Table 1 : *Distribution of sex by age group*

Year	0-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	10-11	11-12	12-13	13-14
Male	4	6	2	3	3	2	4	2	4	8	4	4	1	0
Fem.	5	7	3	3	1	3	0	2	3	2	1	2	0	1

Sex differences in kidney length.

Analysis of the length differences of the right kidney, left kidney and the average length of both left and right kidneys between boys and girls is presented in Table 2, Table 3 and Table 4. Statistically there were no differences in kidney length between boys and girls.

Table 2 :*Analysis of the length differences of the right kidney*

DF:	X Count:	Y Count:	Mean X:	Mean Y:	Unpaired + Value:
78	47	33	84.149	79.333	1.585

Unpaired t-Test: X = Male right kidney Y = Female right kidney $.05 < p \leqslant .1$

Table 3 : *Analysis of the length differences of the left kidney*

DF:	X Count:	Y Count:	Mean X:	Mean Y:	Unpaired + Value:
78	47	33	85.489	80.061	1.763

Unpaired t-Test: X = Male left kidney Y = Female left kidney $.025 < p \leqslant .05$

Table 4 : *Analysis of the length differences of both left and right kidneys*

DF:	X Count:	Y Count:	Mean X:	Mean Y:	Unpaired + Value:
78	47	33	84.819	79.697	1.686

Unpaired t-Test: average right and left kidney; X = Male Y = Female $.025 \leqslant p < .05$

Side differences in kidney length

In 50% of 80 IVP photos the left kidney was longer than the right, 11.25% of the kidney length on both sides were equal and in 37.75% the right kidney was longer than the left one (Fig. 3A for boys; Fig. 3B for girls). A difference in length up to 0.5cm between the left and right kidney were common and only in one case there was a difference of more than 0.5cm, namely 0.6cm.

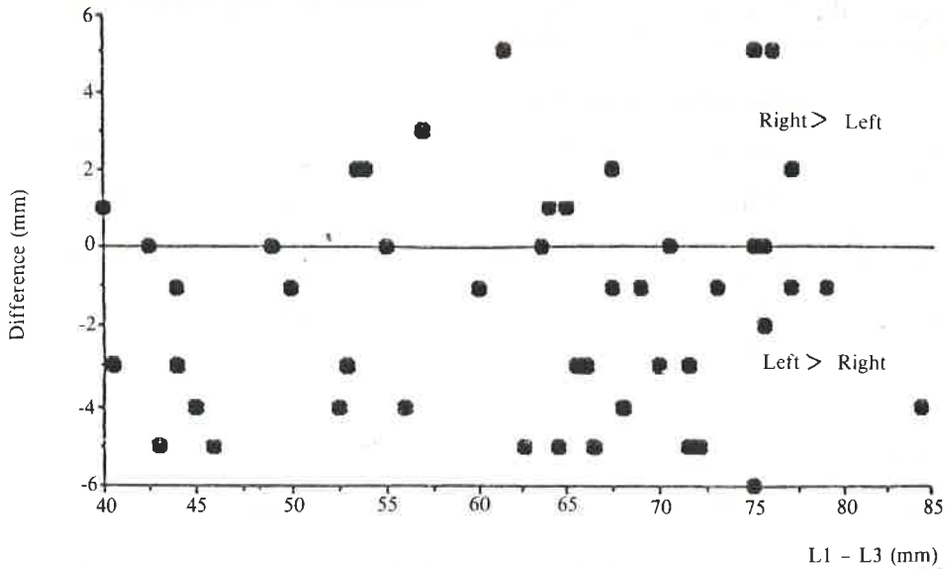

Figure 3A : *Difference of the right and left kidney in 47 boys. Each dot represents a case with a longer right kidney (upper part), longer left kidney (lower part) and equal length at zero line.*

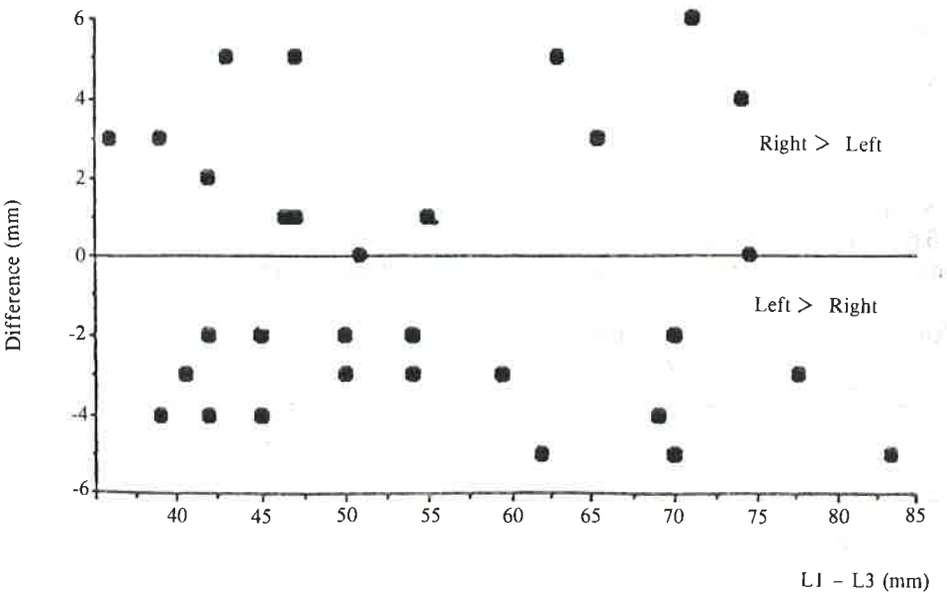

Figure 3B : *Difference of the right and left kidney length in 33 girls. Each dot represents a case as in figure 3A.*

Statistically there was a difference in length between the right and left kidney, the left kidney being longer (Table 5).

Table 5 : *Right kidney length (RKL)*

Mean:	Std. Dev.:	Std. Error:	Variance:	Coef. Var.:	Count:
82.213	13.563	1.516	183.942	16.497	80
Minimum:	**Maximum:**	**Range:**	**Sum:**	**Sum Squared:**	**Missing:**
54	108	54	6577	555243	0

Left kidney length (LKL)

Mean:	Std. Dev.:	Std. Error:	Variance:	Coef. Var.:	Count:
83.3	13.731	1.535	188.542	16.484	80
Minimum:	**Maximum:**	**Range:**	**Sum:**	**Sum Squared:**	**Missing:**
51	110	59	6664	570006	0

Paired t-Test: Y = RKL X = LKL

DF:	Mean X - Y:	Paired + value:
79	-1.087	-3.152

$.0005 < p \leqslant .005$

Kidney length

The correlation observed between kidney length and L1–L3 length, age, body height and body weight are listed in Table 6. Not all data pertaining the body weight and body height were available.

Table 6 : *Correlation coeficient between kidney length and L1–L3 length, age, body height and body weight*

	L1- L3 (n = 80)	Age (n = 80)	Height (n = 31)	weight (n = 63)
Right Kidney length	0.86	0.85	0.86	0.80
Left Kidney length	0.86	0.85	0.83	0.79
Average length Right and Left kidney	0.86	0.85	0.85	0.80

Kidney length and L1–L3 length

Regression analysis between kidney length and the length of L1–L2 is presented in Table 7, each for the right, left and the average of right and left kidney length.

Table 7 : *Correlation of the kidney length and L1–L2 length*

Parameters	Right kidney (n = 80)	Left kidney (n = 80)	R. & L. Kidneys (n = 80)
a (Intercept)	28.37	28.75	28.57
b (Slope)	0.906	0.918	0.912
r (Corr. coeff.)	0.86	0.86	0.86
sd (of the mean)	6.90	6.94	6.73
t	14.80	14.80	14.80

Figures 4, 5 and 6 describe the relation between right kidney, left kidney and the average length of the right and left kidneys respectively, and the length of L1–L2.

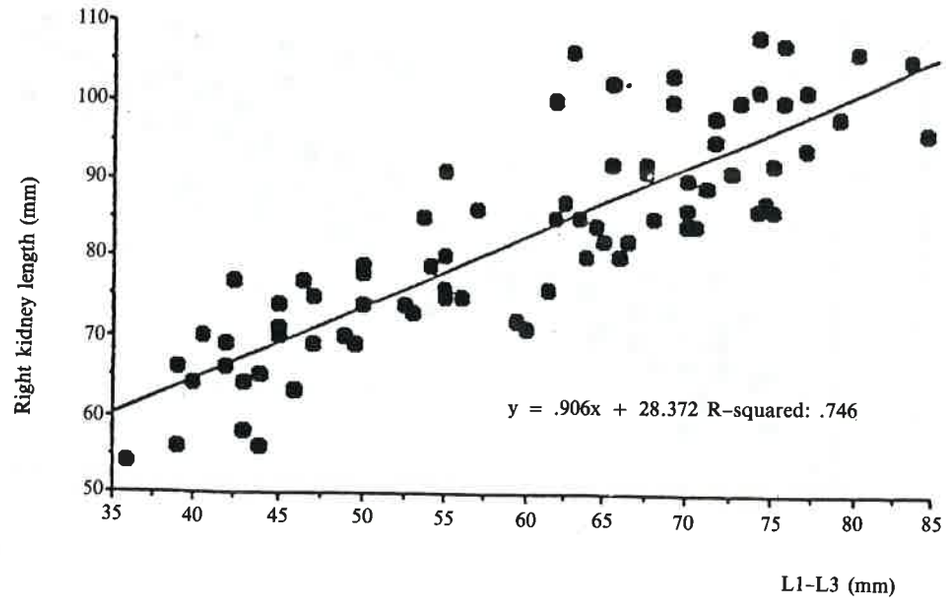

Figure 4 : *Distribution of the right kidney and L1–L3*

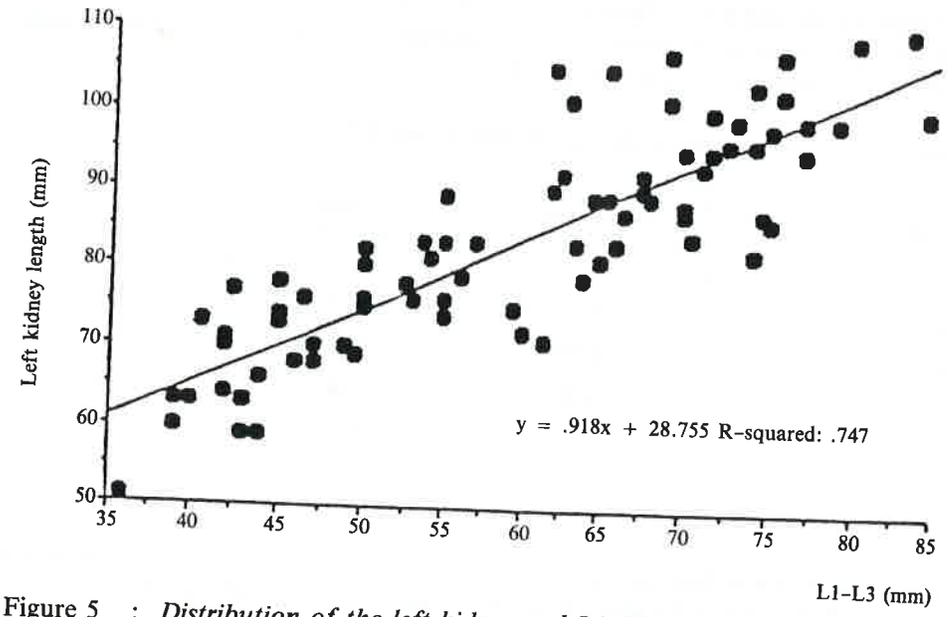

Figure 5 : *Distribution of the left kidney and L1-L3*

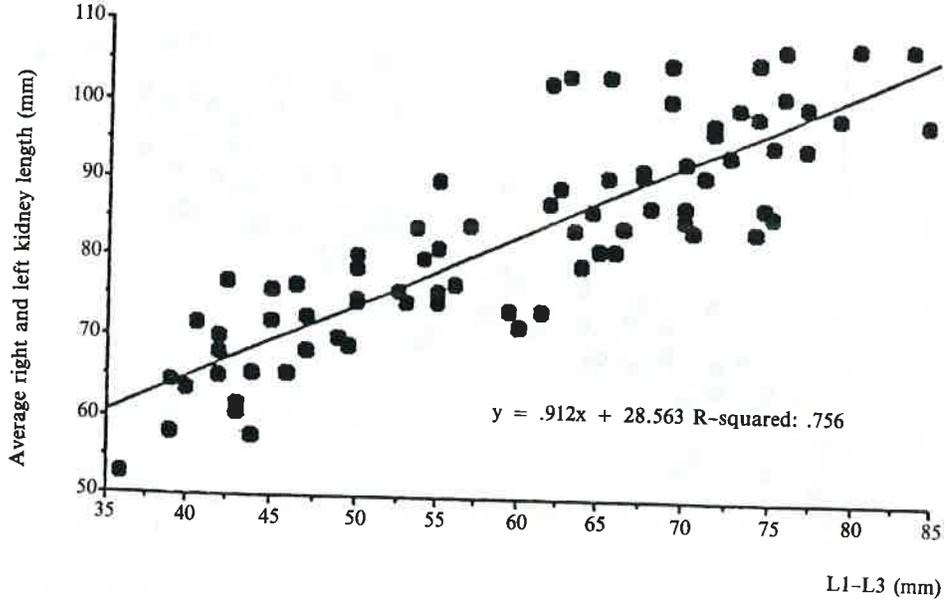

Figure 6 : *Distribution of the average right and left kidney length and L1-L3*

From the equations Y = 0.906X + 28.372 for the right kidney, Y = 0.918X + 28.75 for the left kidney and Y = 0.912X + 28.56 for the average length of right and left kidney, tables of renal length range and L1-L3 length were presented (Tables 8, 9 and 10).

Table 8 : *The normal range (+2 SD and −2 SD) of left kidney length in mm for each mm of L1-L3. Outside the frame, the length of the lumbar segment is given in tens of mm along the Y-axis and in units along the X-axis. Example: length of the lumbar segment is 55 mm, the normal range of the kidney length is 64-91 mm.*

	0	1	2	3	4	5	6	7	8	9
30	-	-	-	-	-	46- 73	47- 74	48- 75	49- 76	50- 77
40	51- 78	52- 79	53- 80	54- 81	54- 82	55- 82	56- 83	57- 84	58- 85	59- 89
50	60- 87	61- 88	62- 89	63- 90	63- 91	64- 91	65- 92	66- 93	67- 94	68- 95
60	69- 96	70- 97	71- 98	72- 99	72-100	73-100	74-101	75-102	76-103	77-104
70	78-105	79-106	80-107	81-108	81-109	82-109	83-110	84-111	85-112	86-113
80	87-114	88-115	89-116	90-117	90-118	91-118	-	-	-	-

Table 9 : *The normal range (+2 SD and −2 SD) of left kidney length in mm for each mm of L1-L3. Outside the frame, the length of the lumbar segment is given in tens of mm along the Y-axis and in units along the X-axis. Example: length of the lumbar segment is 55 mm, the normal range of the left kidney is 65-92 mm.*

	0	1	2	3	4	5	6	7	8	9
30	-	-	-	-	-	47- 74	48- 75	49- 76	50- 77	51- 78
40	51- 79	52- 79	52- 80	53- 80	55- 82	56- 83	57- 84	58- 85	59- 86	60- 87
50	61- 88	61- 89	62- 89	63- 90	64- 91	65- 92	66- 93	67- 94	68- 95	69- 96
60	70- 97	71- 98	71- 99	72- 99	73-100	74-101	75-102	76-103	77-104	78-105
70	79-106	80-107	81-108	81-109	82-109	83-110	84-111	85-112	86-113	87-114
80	88-115	89-116	90-117	91-118	91-119	92-120	-	-	-	-

Table 10 : *The normal range (+2 SD and −2 SD) of the average of right and left kidney in mm for each mm of L1–L3. Outside the frame, the length of the lumbar segment is given in tens of mm along the Y-axis and in units along the X-axis. Example: length of the lumbar segment is 55 mm, the normal range of the average kidney is 65–92 mm.*

	0	1	2	3	4	5	6	7	8	9
30	–	–	–	–	–	47– 74	48– 75	49– 79	50– 77	51– 78
40	52– 79	53– 80	53– 80	54– 81	55– 82	56– 83	57– 84	58– 85	59– 86	60– 87
50	61– 88	62– 89	63– 89	63– 90	64– 91	65– 92	66– 93	67– 94	68– 95	69– 96
60	70– 97	71– 98	72– 99	73–100	74–100	74–100	75–102	76–103	77–104	78–105
70	79–106	80–107	81–108	82–109	83–110	84–110	84–111	85–112	86–113	87–114
80	88–115	89–116	90–117	91–118	92–119	93–120	–	–	–	–

Table 11 : *Correlation kidney length and age*

Parameters	Right kidney (n = 80)	Left kidney (n = 80)	R. & L. Kidneys (n = 80)
a (Intercept)	65.316	66.172	65.744
b (Slope)	0.256	0.260	0.258
r (Corr. coeff.)	0.8461	0.8473	0.8520
sd (of the mean)	7.27	7.33	7.13
t	14.25	14.25	14.25

Kidney length and age.

Regression analysis between kidney length and age is presented in table 11, each for the right kidney, left kidney and the average of rigth and left kidney.

Figures 7, 8 and 9 describe the relation between right kidney, left kidney and the average of right and left kidney length respectively, and age.

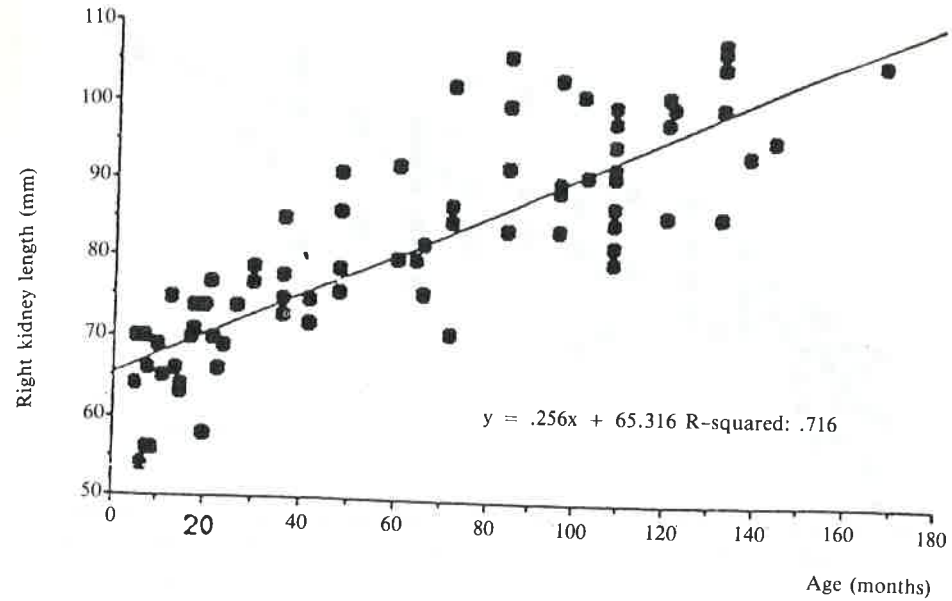

Figure 7 : *Distribution of the right kidney length and age*

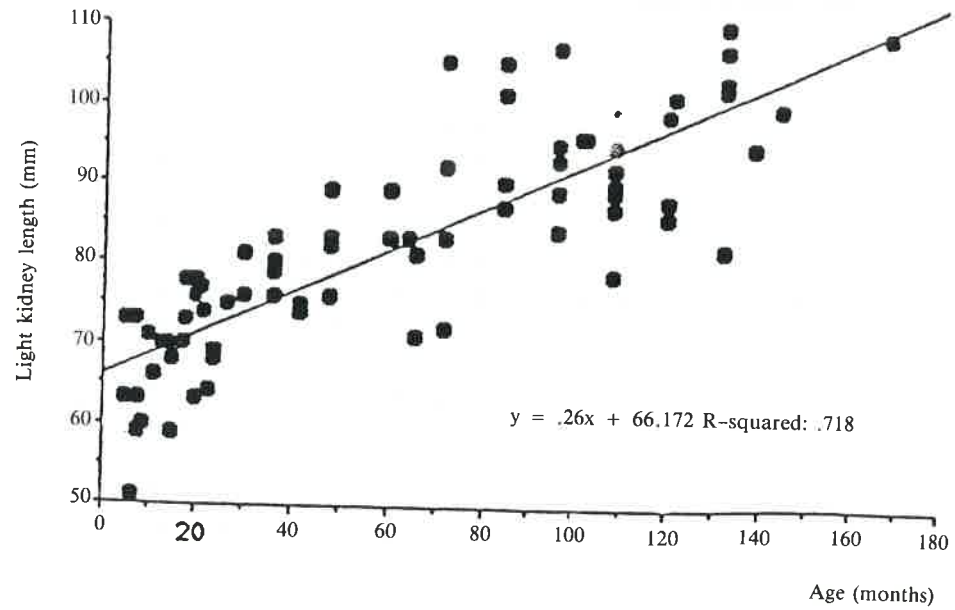

Figure 8 : *Distribution of the left kidney length and age*

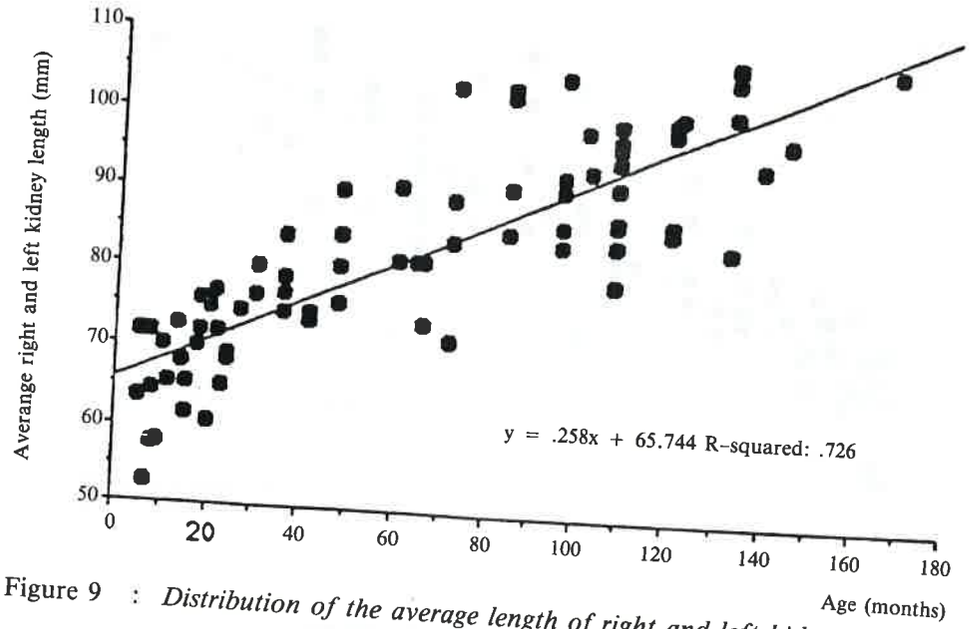

Figure 9 : *Distribution of the average length of right and left kidney and age*

Table 12 : *The normal range (+2SD and —2SD) of right kidney length in mm for each month of age*

	0	1	2	3	4	5	6	7	8	9
0	-	-	-	-	-	54- 80	54- 81	54- 81	54- 81	55- 81
10	55- 81	55- 82	55- 82	56- 82	56- 83	56- 83	56- 83	57- 83	57- 84	57- 84
20	57- 84	58- 84	58- 85	58- 85	58- 85	59- 85	59- 86	59- 86	59- 86	60- 86
30	60- 87	60- 87	60- 87	61- 87	61- 88	61- 88	61- 88	62- 88	62- 89	62- 89
40	62- 89	63- 90	63- 90	63- 90	64- 90	64- 90	64- 91	64- 91	65- 91	65- 91
50	65- 92	65- 92	66- 92	66- 92	66- 93	66- 93	67- 93	67- 93	67- 94	67- 94
60	68- 94	68- 94	68- 95	68- 95	69- 95	69- 95	70- 96	70- 97	70- 96	70- 96
70	70- 97	70- 97	71- 97	71- 97	71- 98	71- 98	72- 98	72- 99	72- 99	72- 99
80	73- 99	73-100	73-100	73-100	74-100	74-101	74-101	74-101	75-101	75-102
90	75-101	75-102	76-102	76-103	76-103	76-103	77-103	77-104	77-104	77-104
100	78-104	78-105	78-105	78-105	79-105	79-106	79-106	77-106	80-106	80-107
110	80-107	80-107	81-107	81-108	81-108	81-108	82-108	82-109	82-109	82-109
120	83-109	83-109	83-110	84-110	84-110	84-111	84-111	85-111	85-111	85-112
130	85-112	86-112	86-112	86-113	86-113	87-113	87-113	87-114	87-114	88-114
140	88-114	88-114	88-115	89-115	89-115	89-116	89-116	90-116	90-116	90-117
150	90-117	91-117	91-117	91-118	91-118	92-118	92-119	92-119	92-119	93-119
160	93-120	93-120	93-120	94-120	94-121	94-121	94-121	95-121	95-122	95-122
170	95-122	-	-	-	-	-	-	-	-	-

Outside the frame, the age is given in tens of months along the Y- axis and in units of month along the X- axis. Example: age is 65 months, the normal range of the right kidney is 69–95 mm (Table 12).

Table 13 : *The normal range (+2 SD and −2 SD) of left kidney length in mm for each month of age. Outside the frame, the age is given in tens of months along the Y-axis and in units of month along the X-axis. Example: age is 65 months, the normal range of the left kidney length is 69–97 mm.*

	0	1	2	3	4	5	6	7	8	9
0	-	-	-	-	-	54- 81	54- 81	54- 82	55- 82	55- 82
10	55- 82	55- 83	56- 83	56- 83	56- 83	56- 84	67- 84	67- 84	57- 84	58- 85
20	58- 85	58- 85	58- 85	59- 86	59- 86	59- 86	59- 86	60- 87	60- 87	60- 87
30	60- 87	61- 88	61- 88	61- 88	61- 89	62- 89	62- 89	62- 89	62- 90	63- 70
40	63- 90	63- 90	63- 91	64- 91	64- 91	64- 91	65- 92	65- 92	65- 92	65- 92
50	66- 93	66- 93	66- 93	66- 93	67- 94	67- 94	67- 94	67- 94	68- 94	68- 95
60	68- 95	68- 96	69- 96	69- 96	69- 96	69- 97	70- 97	70- 97	70- 97	70- 98
70	71- 98	71- 98	71- 98	72- 99	72- 99	72- 99	72- 99	73-100	73-100	73-100
80	73-100	74-101	74-101	74-101	74-101	75-102	75-102	75-102	75-103	76-103
90	76-103	76-103	76-104	77-104	77-104	77-104	77-105	78-105	78-105	78-105
100	79-106	79-106	79-106	79-106	80-107	80-107	80-107	80-107	81-108	81-108
110	81-108	81-108	82-109	82-109	82-109	82-110	83-110	83-110	83-110	83-111
120	84-111	84-111	84-111	84-112	85-112	85-112	85-112	86-113	86-113	86-113
130	86-113	87-114	87-114	87-114	87-114	88-115	88-115	88-115	88-115	89-116
140	89-116	89-116	89-117	90-117	90-117	90-117	91-118	91-118	91-118	91-118
150	91-119	92-119	92-119	92-119	93-120	93-120	93-120	93-120	94-121	94-121
160	94-121	94-121	95-122	95-122	95-122	95-122	96-123	96-123	96-123	96-124
170	97-124	-	-	-	-	-	-	-	-	-

Table 14 : *The normal range (+2 SD and −2 SD) of the average of left and right kidney for each month of age. Outside the frame, the age is given in tens of months along the Y-axis and in units of month along the X-axis. Example: age is 65 months, the normal average kidney length is 69–96 mm.*

	0	1	2	3	4	5	6	7	8	9
0	-	-	-	-	-	53- 80	53- 81	54- 81	54- 81	54- 81
10	55- 82	55- 82	55- 82	55- 82	56- 83	56- 83	56- 83	56- 83	57- 84	57- 84
20	57- 84	57- 85	58- 85	58- 85	58- 85	58- 86	59- 86	59- 86	59- 86	59- 87
30	60- 87	60- 87	60- 87	60- 88	61- 88	61- 88	61- 88	61- 89	62- 89	62- 89
40	62- 89	63- 90	63- 90	63- 90	63- 91	64- 91	64- 91	64- 91	64- 92	65- 92
50	65- 92	65- 92	65- 93	66- 93	66- 93	66- 93	66- 94	67- 94	67- 94	67- 94
60	67- 95	68- 95	68- 95	68- 95	68- 96	69- 96	69- 96	69- 96	70- 97	70- 97
70	70- 97	70- 97	71- 98	71- 98	71- 98	71- 99	72- 99	72- 99	72- 99	72-100
80	73-100	73-100	73-100	73-101	74-101	74-101	74-101	74-102	75-102	75-102
90	75-102	75-103	76-103	76-103	76-103	77-104	77-104	77-104	77-104	78-105
100	78-105	78-105	78-105	79-106	79-106	79-106	79-107	80-107	80-107	80-107
110	80-108	81-108	81-108	81-108	82-109	82-109	82-109	82-110	83-110	83-110
120	83-110	83-111	84-111	84-111	84-111	84-112	85-112	85-112	85-112	86-113
130	85-113	86-113	86-113	87-114	87-114	87-114	87-115	85-115	88-115	88-115
140	88-116	89-116	89-116	89-116	89-117	90-117	90-117	90-117	90-118	91-118
150	91-118	91-118	91-118	91-119	92-119	92-119	92-119	92-120	93-120	93-120
160	93-120	94-121	94-121	94-121	94-121	95-122	95-122	95-122	95-123	96-123
170	96-123	-	-	-	-	-	-	-	-	-

From the equations $Y = 0.256X + 65.316$ for the right kidney, $Y = 0.26X + 66.172$ for the left kidney and $Y = 0.258X + 65.744$ for the average length of right and left kidney, tables of renal length range and age were presented (Tables 12, 13, 14).

Discussion

Since X- ray studies on kidney size are not justified in healthy children, in this study the investigation on kidney length were based on patients having IVP after an urinary tract infection. At the time of examination no clinical and laboratory abnormalities were found. The four- minute IVP photo was chosen for this study since visualisation of renal outline or nephrogram density are they optimum. At the initial radiological examination, 9 IVP photos (10.1%) from 89 IVP photos were discarded. Two IVP photos showed small kidneys, four IVP photos showed hydronephrosis and the remaining three showed respectively renal scarring, calçification in the kidney and vesicolithiasis. Walker et al. (1977) stated that 13% to 17% of the patients with asymptomatic bacteriuria were found to have structural abnormalities. By excluding all factors that may influence kidney length measurements the remaining 83% to 87% of the patients represent subjects in obtaining normal kidney length. In this study 80 IVP photos were patients with no clinical, laboratory and radiological abnormalities. In most studies on renal size the subjects consist of presumable normal children (Effman et al., 1977). New less invasive imaging methods have been introduced. Ultrasound scanning has in the last few years come to occupy an important place in paediatric radiology. There are no radiation involved in this examination and kidney sizes were measured on normal children (Rosenbaum et al., 1984; Dinkel et al., 1985; Tajima, 1987). Rosenbaum et al. (1984) and Dinkel et al. (1985) agree that there was a difference in measurement of kidney size radiographically and ultrasonographycally. Ultrasonographycally renal measurement tends to be subjective and the validity on this new modality is required (Smellie and Normand, 1985).

In this study there were 2 IVP photos of infants younger than 6 months old and two IVP photos of cases older than 12 years old. The vagueness of symptoms and signs of urinary tract infection in very young infants is responsible for the rarity of cases (Glasgow and Overal Jr, 1983). Children older than 12 years old feel more convenient among adult patients. When they need to seek help they prefer to come to the Adult Outpatient Department.

Forty-four IVP photos were of boys and 36 were of girls. The indication to perform IVP in children with urinary tract infection are newborns, boys, girls with pyeolnephritis and girls with second urinary tract infection (Kempe et al., 1980). More boys were investigated in this study because the indication performing IVP in boys were more rigid. In girls IVP were done when they had recurrent infections.

Kidney length

No significant difference in kidney length were encountered between boys and girls in this study. Hodson et al. (1962) and Currarino (1965) had the same findings. On the contrary, in adults there are significant difference in kidney length (Hudson et al., 1962), kidney length in men being longer than in women.

In 80 IVP photos, statistically the left kidney length was longer than the right one. In fifty percent of cases the left kidney length were longer than the right kidney. Both kidney length were equal in 11.25% and in 37.75% the left kidney length were shorter than the right kidney. Currarino (1965) reported that among 44 patients, in whom both kidneys could be measured, the left kidney was found longer than the right in 28 children, the right longer than the left in 10 children and in 6 children both kidneys were equal in length. In their study in whom 227 cases were evaluated and both kidneys could be analyzed, Klare et al. (1980) found that the left organ was significantly longer than the right when analyzed by the Wilcoxon-Test. In 20% of all cases the right kidney was longer than the left and in 10% both kidney length were equal. In measuring the kidney length the position namely right or left

kidney will influence the outcome of the measurement. In this study, most of the differences in length between the left and right kidneys were below 5mm and only in one case the difference was 6mm. Hodson et al. (1962) stated that difference in length up to 5mm between the left and right kidney was not infrequently observed. Currarino (1965) and Klare et al. (1980) in their series found that the length difference between the kidneys was greater than that of this study and Hodson et al. (1962), but most of the difference were still 5mm.

There is an influence of the outcome of kidney length measurement based on the position of the kidney. In this study the right and left kidney were analyzed separately. The correlation between the kidney length and L1–L3 length, age, body height and body weight was strong. The weakest correlation was between the kidney length and body weight and it was still at the level 0.80. It is understandable since body weight are liable to rapid fluctuation (Carroll, 1985). In many statistical measurements in human, beings such as those connected with human genetics, one does not expect a correlation greater than 0.50–0.60 (Hodson et al., 1962), where as in this study, the correlation obtained were in the order of 0.80–0.86. This argues strongly the presence of functional connections. Hudson et al. (1962) concluded from their study that in children there are close correlations between age, body height and kidney length. The correlations were 0.85 and 0.874 for age and body height with kidney length. Klare et al. (1980) in their study of 255 IVP photos confirmed the good correlations between kidney length and body height and L1–L3 length. The correlations were in the order of 0.929 and 0.927 between body height and right and left kidney. The correlations with L1–L2 length were in order of 0.93 and 0.923.

In their study, Eklof and Ringertz (1976) reported an exactly linear correlation between the kidney length and the lumbar segment L1–L3. Using this relationship, the normal range of kidney length was determined for L1–L3 measurements between 2.5 and 11.5cm in a series of 135 patients with normal urography (Table 15). This interval covers all patients in the paediatric age group.

In this study a linear correlation exists between the length of the kidney and L1–L3 length and between the kidney length and age older than 10 months. Using this relationship, tables of normal kidney length range namely betwen +2 Sd and -2 Sd were presented for L1–L2 measurement between 55cm and 85cm. Other tables were also presented between normal kidney range and age between 5 months and 170 months. These tables cover also all patients in the paediatric age group. No attempts were made in determining the normal kidney length range with body height and body weight since the data pertaining both the body height and body weight were not all available.

For charting data on radiological kidney length the author proposes to use chiefly the tables of kidney length range and L1–L3 length. If a congenital anomaly of the vertebra bodies exists, the table of kidney length range and age is the alternative.

Table 15 : *The normal range (±2 SD) of kidney length in mm given for each mm of L1 to L3 length. Outside the frame the length of the lumbar segment is given in tens of mm along the y-axis and in units along the x-axis. Application: Length of the lumbar segment 62mm. Normal range of renal length 72 to 101mm. The normal range of the ratio right kidney lenght/left kidney length corers the interval 1.12 to 0.84*

	0	1	2	3	4	5	6	7	8	9
20	–	–	–	–	–	36– 65	37– 66	38– 67	39– 68	40– 69
30	41– 70	42– 71	43– 72	44– 73	45– 74	46– 75	47– 76	48– 77	49– 78	50– 79
40	51– 79	52– 80	53– 81	54– 82	55– 83	56– 84	57– 85	58– 86	59– 87	60– 88
50	61– 89	62– 90	63– 91	64– 92	65– 93	66– 94	67– 95	68– 96	69– 97	70– 98
60	70– 99	71–100	72–101	73–102	74–103	75–104	76–105	77–106	78–107	79–108
70	80–109	81–110	82–111	83–112	84–113	85–114	86–115	87–116	88–117	89–118
80	90–118	91–119	92–120	93–121	94–122	95–123	96–124	97–125	98–126	99–127
90	100–128	101–129	102–130	103–131	104–132	105–133	106–134	107–135	108–136	109–137
100	109–138	110–139	111–140	112–141	113–142	114–143	115–144	116–145	117–146	118–147
110	119–148	120–149	121–150	122–151	123–152	124–153	–	–	–	–

(From Eklof and Ringertz, 1976).

Summary and Conclusions

1. 10.1% IVP photos of patients with urinary tract infection had radiological abnormalities.
2. There were no difference in kidney length between boys and girls.
3. Statistically there are difference in length between the right and the left kidney.
4. A difference in length up to 0.5cm between the right kidney and left kidney were common. In one case a difference in length more than 0.5cm namely 0.6cm. occurred.
5. Strong correlations exist between kidney length and L1–L3 distance, age, body height and body weight.
6. Tables are presented for charting data on kidney length range with L1–L3 distance and age. Hopefully these table will be of use by the paediatrician, radiologist and urologist in the evaluation and care of growing children with kidney diseases.

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