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# The Position and Size of Radiological Nephrogram in Japanese Preschool Children

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*Department of Clinical and Laboratory Medicine, Akita University School of Medicine, Akita 010-8543, [1]Department of Pediatric Surgery, Fujiwara Memorial Hospital, Akita 010-0201 and [2]Pediatric Surgery, Akita University School of Medicine, Akita 010-8543*

KAYABA, H., CHIHARA, J., URAYAMA, O., KOBAYASHI, Y., HONDA, K., SAITOH, N., TAMURA, H., FUJIWARA, Y., YOSHINO, H., HEBIGUCHI, T. and KATO, T. *The Position and Size of Radiological Nephrogram in Japanese Preschool Children.* Tohoku J. Exp. Med., 1999, **188** (1), 23-29 —— The early detection of retroperitoneal masses in children, such as neuroblastoma, Wilm's tumor, hydronephrosis and cystic renal diseases, has a great clinical importance for the improvement of their prognosis. The kidney is often affected in its size or position by these lesions, and occasionally allows clinicians to find a clue to reach the correct diagnosis before the patient become symptomatic. Since we had no clinically available nomogram on the position and the size of the kidney in Japanese children, we measured the size and position of the kidneys on plain abdominal x-rays in 347 Japanese children in preschool years with a special attention to their relationship with the spine. As a result, the nomogram showed age dependent growth of the kidneys keeping almost the same ratio with the spine, while the distance between the upper pole of the kidney and the spine remained less than 10 mm in all age groups. Our nomogram may be useful not only for picking up the malposition of the kidneys but also for the follow up of the patients with chronic renal diseases affecting the growth of the kidneys. ———— children; kidney; position; retroperitoneal mass 

Pediatricians and pediatric surgeons are paying special attention to the diagnosis of retroperitoneal masses including neuroblastoma, Wilm's tumor, hydronephrosis or cystic renal diseases. These lesions require an accurate diagnosis in an early stage for the successful treatment, and should be followed up

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meticulously. In Japan, the nationwide mass-screening (MS) for neuroblastoma by means of urinary homovanilic acid (HVA) and vanileylmandelic acid (VMA) at six-months of age started in 1985, and it enabled us to detect neuroblastomas in relatively early stage. Yet, no other screening program was developed for other retroperitoneal masses in children. Moreover, the neuroblastomas which can not be detected by the present MS system do still have poor prognosis (Sawada 1992). It is granted that the kidney is often affected in its size or position by retroperitoneal masses. Occasionally, clinicians are discovering the presence of retroperitoneal masses by the abnormality of the size or position of the kidney before the appearance of symptoms. Since, we had no clinically available nomogram on the position and the size of the kidney in Japanese children, we measured the size and position of the kidneys on plain abdominal x-rays in 347 Japanese children in preschool years with a special attention to their relationship with the spine.

## Materials and Methods

The materials consisted of 347 plain abdominal x-rays of children aged one month to six years. These x-rays were selected because of their sharply visualized kidneys from among those taken at Fujiwara Memorial Hospital from 1987 through 1991. The abdominal x-rays were taken in the spine position in an expiratory phase. In each film, the length and width of the kidneys, the distance between the spine and the upper and lower poles, and the level of the upper and lower margins relative to the spine were measured (Fig. 1). For the purpose of

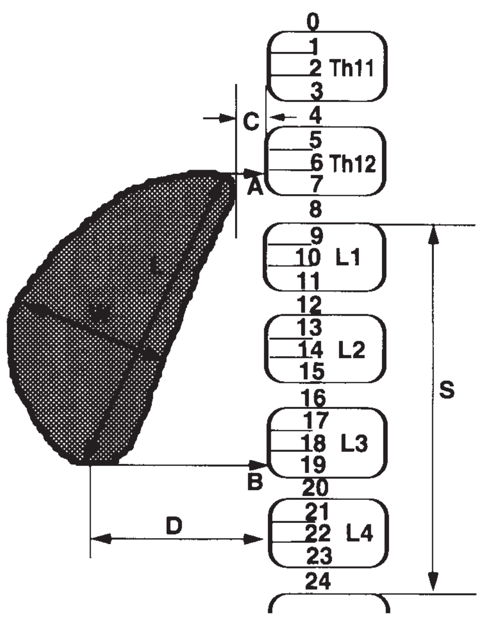


Fig. 1. Measurements of the kidney size and position used in this study (L, the kidney length; W, the kidney width; A, the level of upper margin; B, the level of lower margin; C, the distance between upper pole and the spine; D, the distance between lower pole and the spine; S, the length from the top of L1 to top of L5).

making statistical analysis on the level of the kidney, one vertebral body was divided into three scales and one intervertebral space was counted as one scale, each representing the level. The "0" level was on the 10th thoracic intervertebral space and the scales were numbered downward in order. The normal range of each measurement was defined as the mean value$\pm$2.5 S.D.

## RESULTS

The length of the kidney in each age group showed no significant difference

TABLE 1. *Mean values and standard deviations (S.D.) for the measurement of the kidney*

| Age (Year) | <1 | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|---|
| Number of subjects | 15 | 32 | 28 | 39 | 54 | 69 | 69 |
| Length (mm) | | | | | | | |
| Right | 62.5 | 68.7 | 74.1 | 80.1 | 83.6 | 88.9 | 91.1 |
| S.D. | 5.7 | 6.3 | 5.7 | 7.1 | 5.4 | 6.9 | 6.2 |
| Left | 61.3 | 70.0 | 73.5 | 79.9 | 84.1 | 88.6 | 89.7 |
| S.D. | 4.6 | 6.0 | 6.2 | 5.4 | 6.2 | 5.6 | 7.1 |
| Width (mm) | | | | | | | |
| Right | 30.9 | 33.8 | 35.8 | 39.3 | 41.0 | 42.7 | 44.6 |
| S.D. | 5.7 | 3.0 | 2.4 | 3.2 | 2.8 | 3.1 | 3.8 |
| Left | 31.1 | 34.3 | 35.9 | 38.6 | 40.7 | 43.3 | 43.8 |
| S.D. | 5.4 | 3.1 | 2.8 | 3.4 | 3.2 | 3.6 | 3.7 |
| L1-L4 (mm) | 62.1 | 72.8 | 80.9 | 89.2 | 94.3 | 99.5 | 104.2 |
| S.D. | 5.2 | 4.8 | 4.4 | 5.4 | 5.8 | 4.6 | 6.6 |

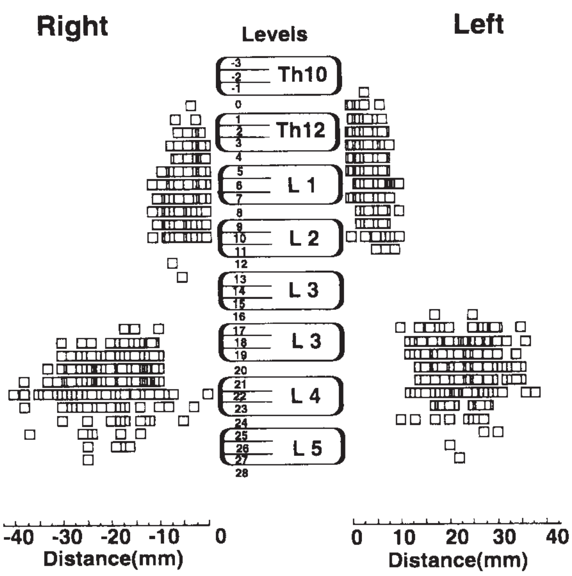


Fig. 2. The position of the upper and lower poles of the kidney. The position of the upper and lower poles of the kidney are shown. Open squares represent the positions of the poles in each subject.

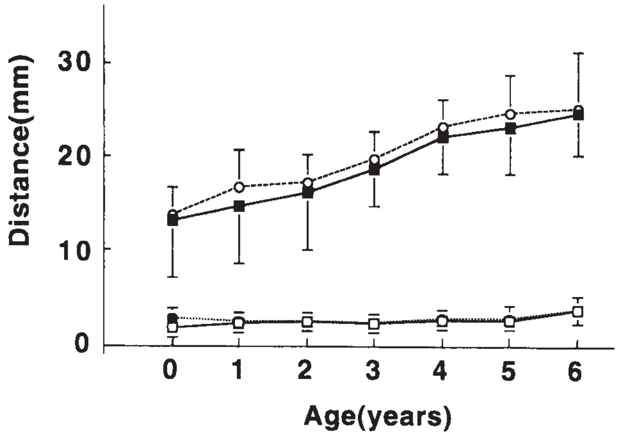


Fig. 3. The distance between the spine and the upper and lower poles of the kidney. The error bar indicates S.D.
(UP, Upper pole; LP, Lower pole; ○, Left lower pole-Spine; ●, Left upper pole-Spine; ■, Right lower pole-Spine; □, Right upper pole-Spine).

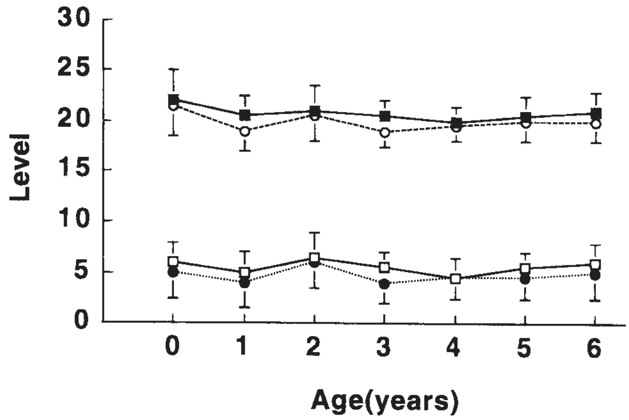


Fig. 4. The level of the upper and lower margins of the kidney. The error bar indicates S.D.
(UM, Upper margin; LM, Lower margin; ○, Left lower margin; ●, Left upper margin; ■, Right lower margin; □, Right upper margin).

from that described by Currarino et al. (1984) (Table 1). During the period of 0 to 5 years of age, the average increase in length of right and left kidney were 5.3 and 5.5 mm/year, respectively. They showed only 2.2 mm and 1.1 mm of respective increase in length of right and left kidney from 5 to 6 years of age. The average annual increase of the width was 2.3 mm/year in right kidney and 2.1 mm/year in left kidney. The length of the kidneys showed strong correlation with the total length of the four lumbar vertebral bodies (right; $r=0.79$, $p<0.01$ and left; $r=0.82$, $p<0.01$). The distance between the spine and the lower pole of the kidney increased as children grew older, while, the upper pole remained within 5 mm of distance in average in every age groups examined (Figs. 2 and 3). The average level of the upper margin was on the 4th to 7th level, namely on the level of 11th thoracic intervertebral space and the body of Th12 irrespective of

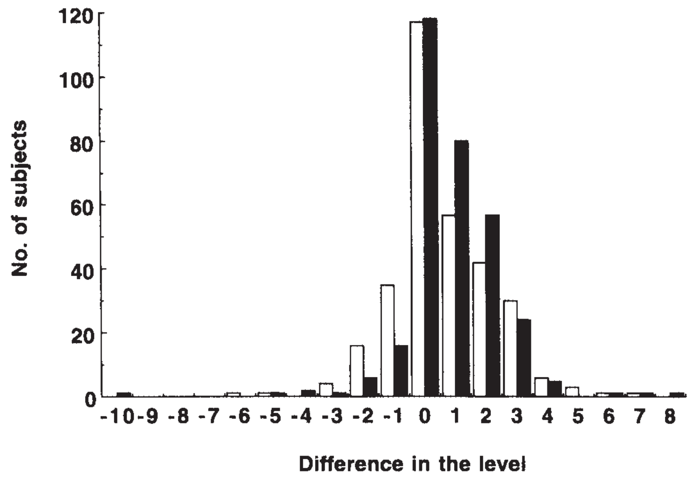


Fig. 5. The distribution of the difference in the level between the margins of the right and left kidney. The difference in the level is calculated as (the level of right upper [lower] margin)-(the level of left upper [lower] margin). (□, Upper margin; ■, Lower margin).

age. The lower margin was on the level of 19 to 22 (L3–4) (Fig. 4). The margins of the right kidney tended to be a little lower than those of the left kidney. The left lower margin lower than that of the right was seen in only 8.8% of subjects. In 96.1% of the subjects, the difference in the level of the margins between the right and left kidneys was within 4 scales (Fig. 5).

## Discussion

Retroperitoneal masses in children are entities of clinical importance especially for pediatric surgeons, since they include surgically curable or correctable lesions such as neuroblastoma, Wilm's tumor or cystic renal diseases. A delay in the diagnosis may allow these lesions to progress beyond the range of surgical treatment. With the aim of detecting neuroblastomas in early stages, the nationwide MS for neuroblastoma using HVA and VMA at six-months of age was put into practice in Japan in 1985. Seventy percent of patients with neuroblastomas were detected with the present MS system and they tended to have a good prognosis. Yet, the neuroblastomas which are not detectable in the present MS do have a poor prognosis. Ishimoto et al. (1990) hypothesized that the neuroblastomas detectable and those undetectable with the present MS system in the first year of life are belong to different kind, although the MS can detect both of the neuroblastomas with favorable and unfavorable prognosis(Tanaka et al. 1998). Suita et al. (1998) reported that MS at 6 months of age was not found to improve substaintially the prognosis of patients with unfavorable neuroblastoma identified over 1 year of age. Some attemps were made for the mass-screening for retroperitoneal masses in children using ultrasonography, however, there remained many problems to be solved before put them into practice (Kayaba et al. 1991). At present, the detection of retroperitoneal masses, including the neuroblastomas undetectable by MS, is entirely depending on the general practitioners and pediatricians working in the front line. It is granted that the kidney is often affected in its size or position by retroperitoneal masses, which by chance gives clinicians to notice the presence of the lesions before they present symptoms.

Applying the nomogram we made in this study, we carried out a retrospective study on the position of the kidneys in children who underwent surgery for retroperitoneal masses(retroperitoneal neuroblastoma: $n=16$, Wilm's tumor: $n=8$, hydronephrosis: $n=14$), which showed that all the patients with retroperitoneal neuroblastomas had a displacement of the kidney exceeding the normal range(the average value$\pm$2.5 S.D.) in either lateral (56.3%) or craniocaudal (68.8%) direction in their preoperative abdominal plain x-ray films, irrespective of the stages of the disease. Moreover, all the patients with Wilm's tumor and 71.4% of patients with surgically corrected hydronephrosis had abnormal values in the size of the kidney in their preoperative abdominal x-ray films (data not shown). Though, anteroposterior displacement of the kidney is not detectable in our nomogram, it is worth notifying again the clinical importance of the abnormality in the position of the kidneys, as well as their abnormality in size.

The nomogram of the kidneys presented in this study showed age dependendent increase of the size. On the other hand, the position of the kidneys showed little variation according to the age of the children studied. Currarino and Winchester (1965) reported that the level of the center of the renal pelvis was between L1 and L2, and that the right kidney was lower than the left in approximately two-thirds of the cases, and the left kidney was lower than the right in 6%, which is compatible with our results. The age independent, steady position of the kidney is an extremely useful as an indicator for the mass effect in retroperitoneal lesions. In some chronic renal diseases, the atrophy of the affected kidney with or without hypertrophy of contralateral kidney is observed. This phenomena also occurs in some cases after the surgical correction of hydronephrosis or vesicoureteral reflux. The nomogram of the kidney size may be also useful in the follow up of renal growth in chronic renal diseases. On every abdominal x-ray film, even in the case of a foreign body in the gastrointestinal tract, attention should be paid for the shadows in retroperitoneum.

In conclusion, our nomogram of the kidney in children in preschool years may be useful not only for picking up the malposition of the kidneys but also for the follow up of the growth of the kidneys affected with chronic renal diseases.

## References

1) Currarino, G. & Winchester, P. (1965) Position of the kidneys relative to the spine, with emphasis on children. *Am. J. Roentgen.*, **95**, 409-412.
2) Currarino, G., Williams, B. & Dana, K. (1984) Normal values for kidney length in children correlated with age. *Radiology*, **150**, 703-704.
3) Ishimoto, K., Kiyokawa, N., Fujita, H., Yabuta, K., Ohya, T., Miyano, T., Shinohara, T. & Sera, Y. (1990) Problems of mass screening for neuroblastoma: Analysis of false-negative cases. *J. Pediatr. Surg.*, **25**, 398-401.

4) Kayaba, H., Kato, T., Hebiguchi, T., Yoshino, H. & Koyama, K. (1991) Mass Screening of retroperitoneal tumors in children with ultra sonography: A preliminary study. *Jpn. J. Pediatr. Surg.*, **23**, 627-632. (in Japanese)
5) Sawada, T. (1992) Mass Screening for Neuroblastoma. *Jpn. J. Pediatr. Surg.*, **24**, 9-112. (in Japanese)
6) Suita, S., Tajiri, T., Akazawa, K., Takamatsu, H., Mizote, H., Ohgami, H., Kurosaki, N., Hara, T., Okamura, J., Miyazaki, S., Sugimoto, T., Kawakami, K., Tsuneyoshi, M., Tasaka, H., Yano, H., Akiyama, H. & Ikeda, K. (1998) Mass screening for neuroblastoma at 6 months of age: Difficult to justify. *J. Pediatr. Surg.*, **33**, 1674-1678.
7) Tanaka, T., Sugimoto, T. & Sawada, T. (1998) Prognostic discrimination among neuroblastomas according to Ha-ras/trk A gene expression: A comparison of the profiles of neuroblastomas detected clinically and those detected trough mass screening. *Cancer*, **83**, 1626-1633.