STUDY ON RADIOHIPPURAN RENOGRAM IN MOVALE KIDNEY

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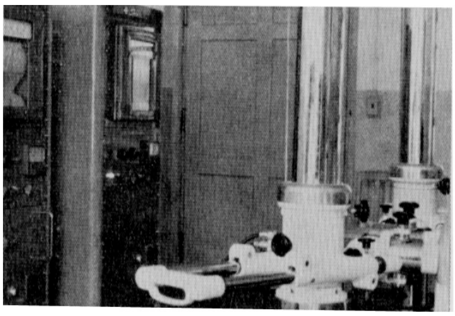
Since radioisotope was applicated in the renal function test by Oeser and Billon (1952), Winter (1956)[1] reported the clinical cases of radioisotope renogram which measured the γ-ray from the exterior of the body. Radioactive diodrast, urokon, hypaque and miokon etc. were used previously, but recently radiohippuran-I (radioiodo-hippurate sodium), most appropriate to the renal faunction test, has been used commonly.

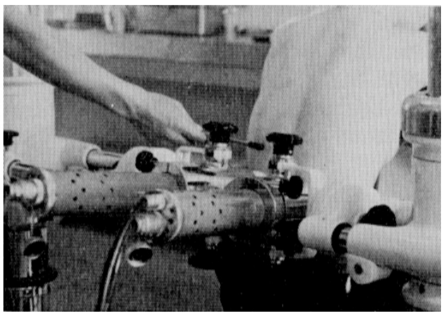
In this study, variation of renogram in the urological renal diseases especially movable kidney using radiohippuran were investigated by Shimazu's Renogram Apparatus. (Fig. 1. A)

METHOD AND PROCEDURES

The patient takes 500 cc of water 30 minutes prior to examination and 0.4 μc radiohippuran per kg was injected intravenously. The detector was projected to the patient's back where situated to the kidney and then renograms were taken by the supine and alightly flexed sitting posture. (Fig. 1 B) Pyelogram, perirenal oxygen insufflated nephrogram and renal palpation may be a help to determine the situation of the kidney. Most sensitive portion



A



B

FIG. 1. Shimazu's Renogram Apparatus.
The detector was projected to the patient's back where situated to the kidney and then renograms were taken by the supine and slightly flexed sitting posture.

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to the γ-ray following the intravenous injection of 0.04 μc radiohippuran per kg may be a suitable site to project the detector, where may be the suspected situation of the kidney.

RESULTS

Radiohippuran renogram were taken on 62 patients including 42 cases of the movable kidney and 20 cases of the normal kidney and their renograms were investigated.

1) Findings of Renogram

Renogram was recorded on the Shimazu's chart with speed 10 mm/min. Vertical axis shows counts per second (C.P.S.) of the γ-ray activity and horizontal axis shows time (min. or sec.). (Fig. 2)

Curve of renogram rapidly elevates following the intravenous injection of the radiohippuran. A mark A of this curve, is called as initial spike or initial rise, shows initial irrigation of the radiohippuran to the kidney and surrounding tissue, and this height means renal vascularity or renal blood volume. This curve elevates gradually and then descends. A mark B, an apex of this curve, is called as segment B or more gradual secondary rise. A to B shows tubular secretion of the concentrated radiohippuran as secretory phase. The steepness and height may be in propotion to the function of the kidney. It is presumed that the hippuran may be rapidly cleared away from blood stream in this phase. Then the segment B shifts to the so-called excretory phase in which B descends to the height corresponding to the A. It is thought that the hippuran is being excreted from the kidney and renal or perirenal vessels in this phase. (A′) A half height of the B represents as a mark B′ which shows a half-life of the hippuran in the human kidney, and C represents γ-ray activity 15 min. after injection.

In order to investigate the renal function by the renogram, the various renograms were measured, in which T_A, T_B and T_H indicate the time of the

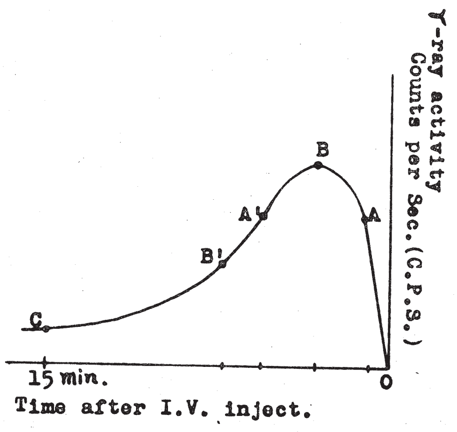


FIG. 2. Renogram and its significance[2].
O-A: Renal vascularity
A-B: Secretory phase
B-C: Excretory phase
A: Blood volume of the kidney and surrounding tissue
B: Tubular secretion of hippuran concentrating the labeled contrast medium in the kidney
A′: Time returned to A level
B′: Time returned to 1/2 of the B peak
C: Fifteen minutes level of activity

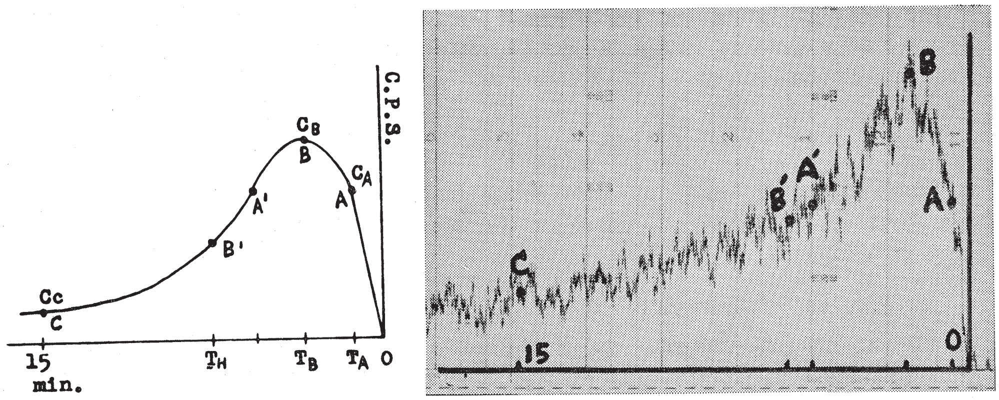


FIG. 3. Measurement of renogram.

A, B and B′ following radiohippuran injection respectively, and C_A, C_B and C_C indicate the γ-ray activity of the A, B and C respectively.

A mark R_a ($=C_B/C_A$) indicates the ratio between C_B and C_A. R_a more than 1.0 shows the existence of the secretory phase (C_B). A mark K ($=C_B-C_A/T_B-T_A$) indicates tan θ on the renogram curve. Larger the K shows higher the B which means quick steepness of the hippuran and remarkable tubular secretion. K also shows the periodical ratio between renal accumulation and tubular excretion. Then the excretion of the hippuran investigated by the diminution ratio in the human kidney after 15 minutes. A mark E[$=(C_B-C_C/C_B)\times 100\%$] indicates the diminution ratio of the C_B which shows highest γ-ray activity.

2) Normal Renogram and Determination of its Normal Limit

Renograms were measured with 20 selected cases of the normal bilateral kidneys proved by the urological examination and its normal limit was determined. As shown in the Fig. 3 to 6 and Table 1, mean values at sitting posture were obtained as follows:

Right kidney; $T_A=33$ sec. $C_A=414$ C.P.S.
$T_B=3$ min. 21 sec. $C_B=736$ C.P.S.
$T_H=7$ min.
$C_C=154$ C.P.S.
$R_a=1.78$ $K=2.03$ $E=78.9\%$

Left kidney; $T_A=32$ sec. $C_A=421$ C.P.S.
$T_B=3$ min. 29 sec. $C_B=735$ C.P.S
$T_H=7$ min. 21 sec.
$C_C=168$ C.P.S.
$R_a=1.78$ $K=1.96$ $E=77.1\%$.

In this study, lowest C_A was 300 C.P.S. and T_B showed 1 min. 50 sec. to 6 min. Lowest C_B was 550 C.P.S. and T_H showed within 8 min. 42 sec. in 90% of the cases. R_a showed more than 1.50 in the 39 out of 40 renograms.

TABLE 1. Mean Value of Renogram
20 cases of normal kidney and 42 cases of movable kidney

				A		B		A′	B′	C	R_a	K	E
Case	Side	Grad	No.	T_A sec.	C_A C.P.S.	T_B sec.	C_B C.P.S.	sec	T_H sec.	C_O C.P.S.			%
Normal	R		20	33	414	201	736	376	420	154	1.78	2.03	78.9
			min.	18	320	120	550	210	260	100	1.47	1.04	70.2
			max.	60	550	360	1000	510	590	225	2.06	3.75	88.0
	L		20	32	421	209	735	373	441	168	1.78	1.96	77.1
			min.	18	330	132	550	312	276	100	1.50	1.04	67.7
			max.	48	520	345	900	498	570	220	2.35	4.26	86.7
Movable Kidney	R	2nd	20	37	396	256	746	526	588	258	1.91	1.83	64.3
			min.	18	280	90	550	228	302	100	1.47	0.92	43.0
			max.	54	625	540	1150	900↗	900↗	500	2.71	3.79	86.7
	L	1–2nd	20	33	401	242	817	579	557	243	2.06	2.14	70.2
			min.	18	270	114	510	234	288	100	1.55	0.75	38.8
			max.	60	625	372	1125	900↗	900↗	520	2.75	3.73	83.3
	R	2nd	15	27	400	262	786	607	577	303	2.03	2.02	60.7
			min.	18	250	126	550	432	450	180	1.54	0.72	30.8
			max.	48	650	468	1000	900↗	900↗	540	2.74	4.79	80.0
	L	2nd	15	27	382	243	792	582	582	271	2.14	2.14	65.8
			min.	18	200	150	520	318	336	120	1.48	0.99	31.3
			max.	48	570	378	1100	900↗	900↗	550	2.60	4.10	81.0
	R	3rd	7	29	299	368	677	900↗	900↗	430	2.30	1.36	38.7
			min.	18	200	174	400	552	810	230	1.89	0.69	8.9
			max	42	360	840	900	900↗	900↗	820	2.75	2.16	57.6
	L	3rd	7	26	335	333	731	900↗	900↗	396	2.22	1.46	45.1
			min.	18	200	186	480	690	540	200	1.84	0.49	4.4
			max.	30	470	594	1100	900↗	900↗	650	2.73	2.96	68.8

900↗: over 900 seconds (over 18 minutes)

Lowest K was 1.04, it means that the angle of the AB to the base line is more than 45 degrees. E diminished more than 70% in the 38 out of 40 kidneys.

From the above mentioned results, normal limits of the renogram were determined as follows:

a) A ; $C_A \geqslant 300$ C.P.S.
b) B ; $C_B \geqslant 550$ C.P.S. 100 sec. $< T_B \leqslant 360$ sec.
c) B′; $T_H \leqslant 522$ sec.

d) C ; C_C(15 min. after I.V. injection) $\leqslant$ 250 C.P.S.
e) R_a; $\geqslant$ 1.50
f) K ; $\geqslant$ 1.00
g) E ; $\geqslant$ 70.0%

Mean values at the supine posture were obtained as follows: $T_A = 24$ sec. $C_A = 220$ C.P.S. $T_B = 4$ min. 30 sec. $C_B = 560$ C P.S. $T_C = 9$ min. 48 sec. $C_C = 120$ C.P.S.

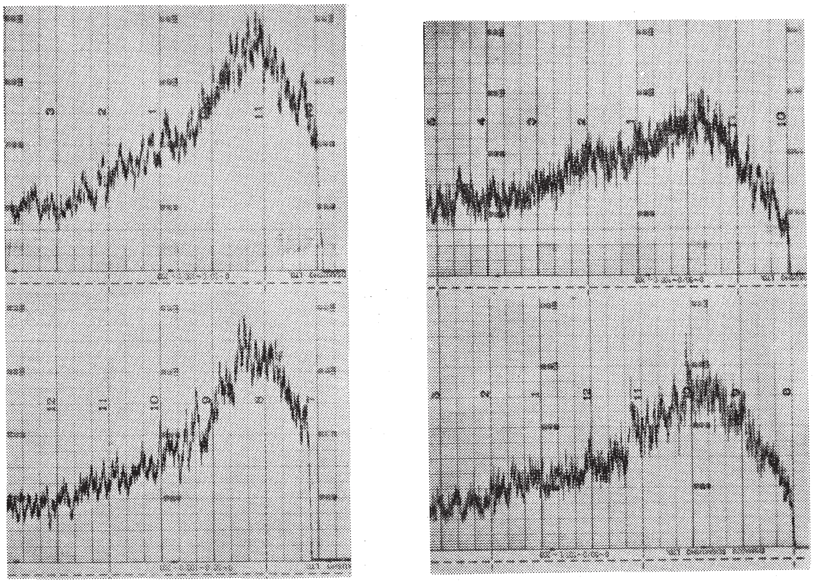


FIG. 4. Renogram at sitting and supine posture in the same normal human kidney.
Right upper: Right kidney at sitting posture
Left upper: Right kidney at supine posture
Right lower: Left kidney at sitting posture
Left lower: Left kidney at supine posture

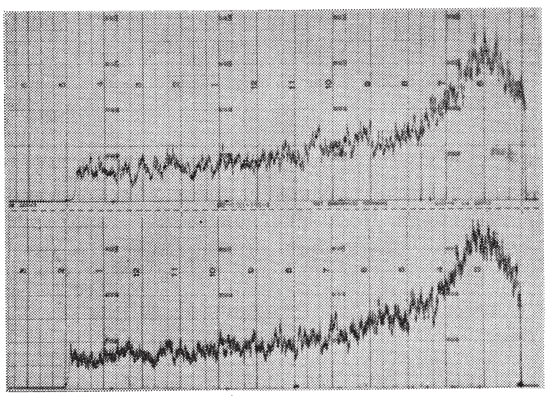


FIG. 5. Thirty minutes renogram of normal human.
Upper: Right kidney Lower: Left kidney

$R_a=2.55$ $K=1.38$ $E=78.5\%$. They showed prolongation of the T_B, decrease of C_A and C_B in comparison with mean values at the sitting posture, but C_C and E showed without any change.

Excretion of the hippuran in the urine after 30 min. showed average 62.0% in 10 normal cases, 75.7% was excreted after an hour in 5 cases and 95.7% was excreted after 12 hours in all cases.

Fig. 6 shows the renogram and excretion of the hippuran into the urine collecting bag in the case of unilateral kidney that had cutaneous ureterostomy. The hippuran was excreted rapidly in the urine. This case looks like the urine is somewhat accumulated into the dilated pelvis, then after excreted through the Nelaton's catheter. In the case of the unilateral kidney, renogram was taken with one detctor projected to the remained kidney and another to the vesical region. The hippuran was excreted rapidly into the bladder similarly.

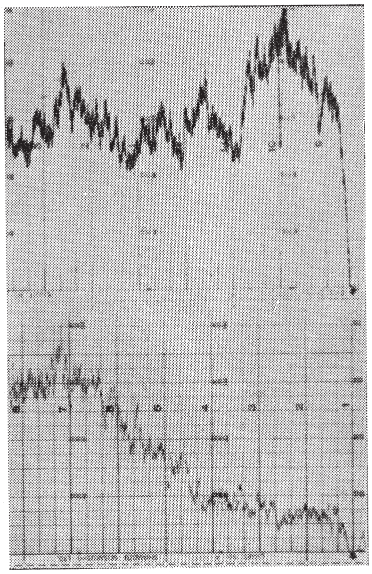


FIG. 6. Excretion of hippuran from kidny.
Upper: Renogram of the unilateral kidney with cutaneous ureterostomy.
Lower: Excretion of the hippuran into the urine collecting bag.

3) Renogram in the Case of the Renal Failure

Renograms in the case of the renal failure and mechanical urinary obstruction were taken in order to differentiate with normal renogram.

a) Renal Anuria (Acute Renal Failure)

Fig. 7 shows the renogram of 4 days anuria patient who suffered from chronic leucemia and had no urinary excretion by the ureteral catheterization and administration of diuretica. The patient died after 7 days, the renogram showed complete failure in the right kidney and remained only a little function in the left.

b) Renogram of the Obstructive Urinary Calculus

Fig. 8 show the renograms of the hydronephrotic kidney secondery to the obstruction of calculus into the pelvis or ureter. Renal vascularity and secretory phase showed normal but accumulation of the hippuran was observed in the case of the obstructive ureteral calculus, it may result from disturbance of urinary excretion. In the unobstructive ureteral calculus it showed disturbance of urinary excretion but without any accumulation of the hippuran.

In the cases of the disturbance of renal function due to existence of long dated calculi, renal tuberculosis or tumors, renogram curve shows parallel to the base line with low γ-ray activity.

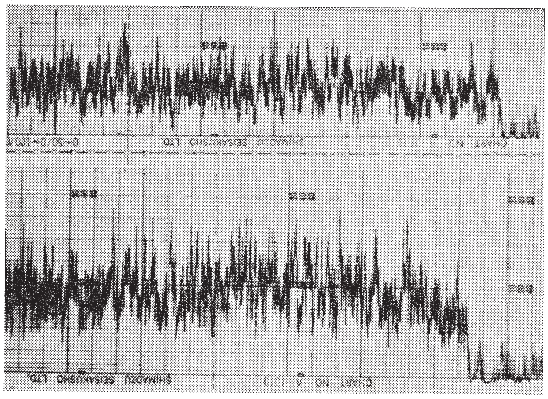
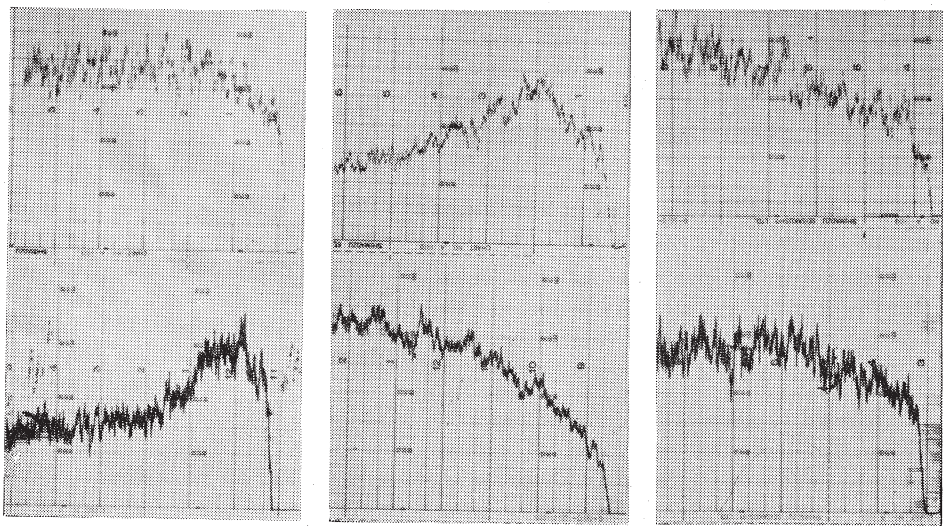


FIG. 7. Renogram of the chronic leucemic patient 4 days after anuria.
Upper: Right kidney Lower: Left kidney



a b c

FIG. 8. Renograms of the ureteral calculus.
a. Right obstructive ureteral calculus left normal.
b. Right unobstructive ureteral calculus left coral like calculi.
c. Bilateral coral like calculi. (Upper: Right kidney, Lower: Left kidney)

4) *Various Factors Influenced to the Renogram*

It is widely known that renogram may be influenced by the various factors such as distance and angle between detector and kidney, displacement of the kidney by the patient's respiration or abdominal pressure, posture of the patient, amount of injected radiohippuran, water intake, body weight, surrounding tissues and organs and mental status.

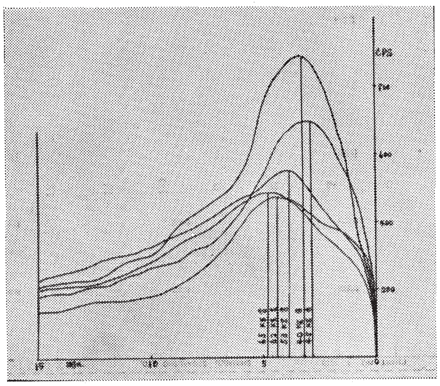


FIG. 9. Renograms of the normal human with various body weight, injected 15 μc radiohippuran each other.

a) Relationship to Body Weight

Fig. 9 shows the renograms of the normal human with the various body weight, injected 15 μc radiohippuran each other. Heavier the body weight, C_A and C_B become lower and their duration prolongs. K becomes lower. This may be related to the distance to the kidney and the dilution of the hippuran in the blood stream. So injected dose of hippuran should be considered with patient's body weight.

b) Relationship between Detector and Kidney

Relationship to the angle between detector and kidney was studied with the nephrectomized kidney of the dog injected radiohippuran through the renal artery previously.

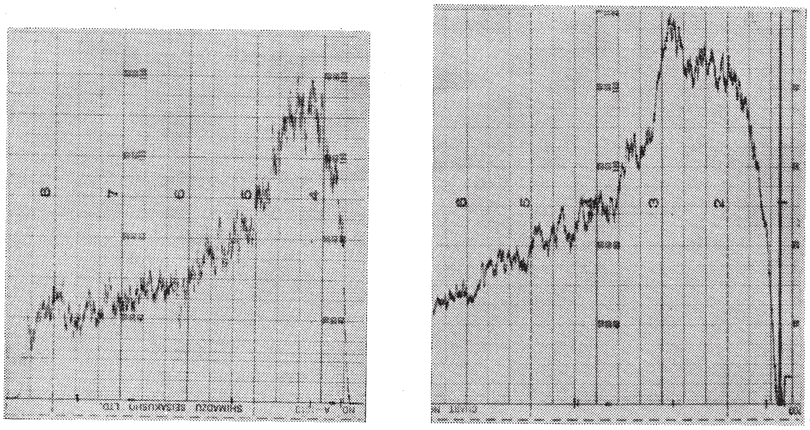
If the kidney rotated 45 degrees laterally, γ-ray activity diminishes 19%, if rotated 90 degrees, namely longitudinal axis of the kidney and detector becomes straightly, diminishes 23.3%. In the case the detector projected to the center of kidney in 5 cm distance. If displacing the detector 5 cm laterally, γ-ray activity diminishes 60%. From the above mentioned results determination of the exact site of the kidney, namely exact projection of detector to the renal region, may be a quite important factor to obtain a correct renogram.

c) Relationship to Water Intake

Renogram showed high prolonged durated C_B and delayed excretion at dehydrated status, but rapid elevation and shorted durated B at hydrated status. The steepness of B increased quickly at hydrated status, but its activity is lower and rapidly excreted than that of at dehydrated status. So we gave 500 cc of water prior to the examination to correct it as Meade[2] did.

d) Relationship to the other Organs

In order to study the hippuran influenced to the liver, renograms were taken with projected the detectors to the liver portion and nephrectomized renal portion in the patient who performed nephrectomy. γ-ray activity at nephrectomized side had no special change, so it is presumed that radiohip-



Hydrated Dehydrated

FIG. 10. Renogram of the same patienat the hydrated and dehydrated staturs.

puran existed in the blood stream and other organs may be collected to the kidney in a short time and had no remarkable influence to the liver.

When projected the third detector to the Jod affined thyroid gland and took the renograms simultaneously, γ-ray activity showed 112 C.P.S. after 2 min. 30 sec., 104 C.P.S. after 5 min., 68 C.P.S. after 10 min., 66 C.P.S. after 15 min., 58 C.P.S. after 30 min. and nothing after 24 hours. When projected to the carotis portion, γ-ray also showed extremely low value and disappeared rapidly.

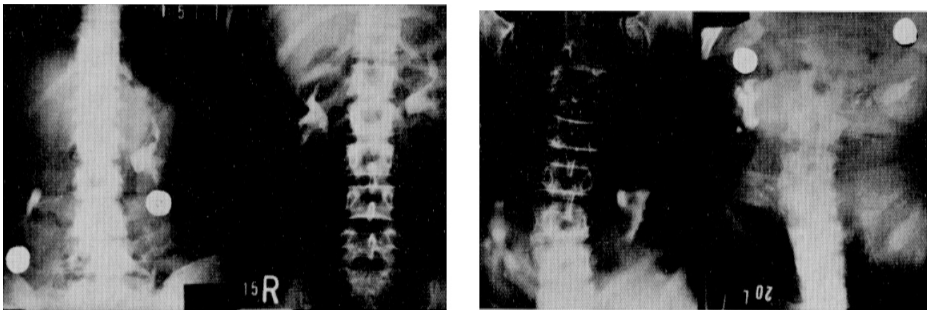
5) *Renogram in Movable Kidney*

Movable kidney was classified by Shimizu and Yoshikawa's[3] classification, namely lower calyces of the erect intravenous pyelogram descended to the lower margin of 3rd lumbar spine as 1st grade, to the lower margin of 4th lumbar spine as 2nd grade and to lower than lower margin of 4th lumbar spine as 3rd grade.

Supine and erect pyelograms following intravenous injection of 60% urografin and position of the detector projected to the kidney most sensitive to the radiohippuran were investigated. Position of the kidney at erect intravenous pyelogram was higher than that of detector, but they were nearly at similar position in the normal kidney.

In 24 cases (57.1%) out of 42 cases of movable kidney, position of the kidney at erect pyelogram were higher than that of detector and remained cases showed nearly at similar position. (Fig. 11)

So it should be paid attention that actual descendence of the kidney in the movable kidney is more marked that of erect intravenous pyelogram, and we can say that the movable kidney may be diagnosed easier and more accurate by the position of detector projected.



Erect Supine Erect Supine
A B

FIG. 11. Position of the kidney at erect pyelogram was higher than that of detector.
A: IVP of 2nd grade right movable kidney, detector projected just above the pelvic bone.
B: IVP of 3rd grade bilateral movable kidney, detector projected to the pelvic fossa.
●: Position of projected detector.

a) Renogram of 2nd Grade Right Movable Kidney and 1st or 2nd Grade Left Movable Kidney

Renograms at sitting posture in the 20 cases were taken and obtained results as follows: (Table 1 and Fig. 12, 13, 14)
Mean values of right renogram;

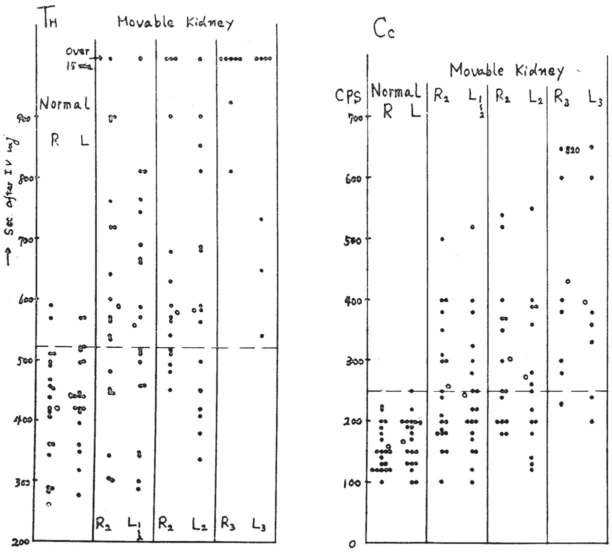


FIG. 12. Distribution of T_H and C_C value.
●: Mean value.

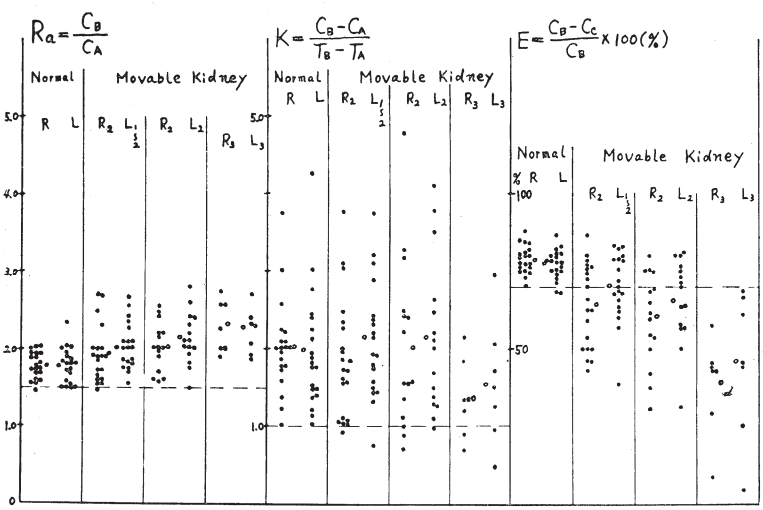
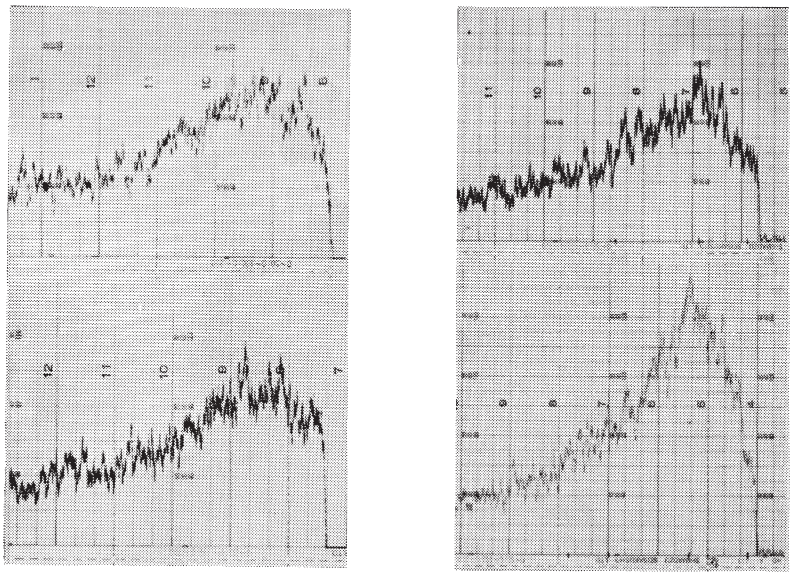


FIG. 13. Distribution of R_a, K and E value.
●: Mean value.



a b

FIG. 14. a. Renograms of right 2nd grade, left 1st grade movable kidney.
b. Renograms of right 2nd grade movable kidney and left normal kidney.
(Upper: Right kidney Lower: Left kidney)

T_A=37 sec. C_A=396 C.P.S. T_B=4 min. 16 sec. C_B=746 C.P.S. T_H=9 min. 48 sec. C_C=258 C.P.S. R_a=1.91 K=1.83 E=64.3% Mean values of left renogram;
T_A=33 sec. C_A=401 C.P.S. T_B=4 min. 02 sec. C_B=817 C.P.S. T_H=9 min. 17 sec. C_C=243 C.P.S. R_a=2.06 K=2.14 E=70.2%

Renogram of 2nd grade right movable kidney showed some variation of E, C_C and T_H, but without any change of A and B. It means somewhat prolongation of the excretory phase. Variation of left renogram in this group were lesser than that of right renogram.

b) Renogram of Bilateral 2nd Grade Movable Kidney

Renograms at sitting posture in the 15 cases were investigated and obtained results as follows: (Table 1 and Fig. 12, 13, 15)

Mean values of right renogram;
T_A=27 sec. C_A=400 C.P.S. T_B=4 min. 22 sec. C_B=786 C.P.S. T_H=9 min. 37 sec. (more than 15 min. in 3 cases)
C_C=303 C.P.S. R_a=2.03 K=2.02 E=60.7%

Excretory phase of right renogram in this group was prolonged more than that of right renogram in the first group.

Mean values of left renogram;
T_A=27 sec. C_A=382 C.P.S. T_B=4 min. 22 sec. C_B=792 C.P.S.
T_H=9 min. 42 sec. (more than 15 min. in one case)
C_C=271 C.P.S. R_a=2.14 K=2.14 E=65.8%

Excretory phase of left renogram was slightly shortened than right side in this group, but nearly similar to 2nd grade right movable kidney in 1st group.

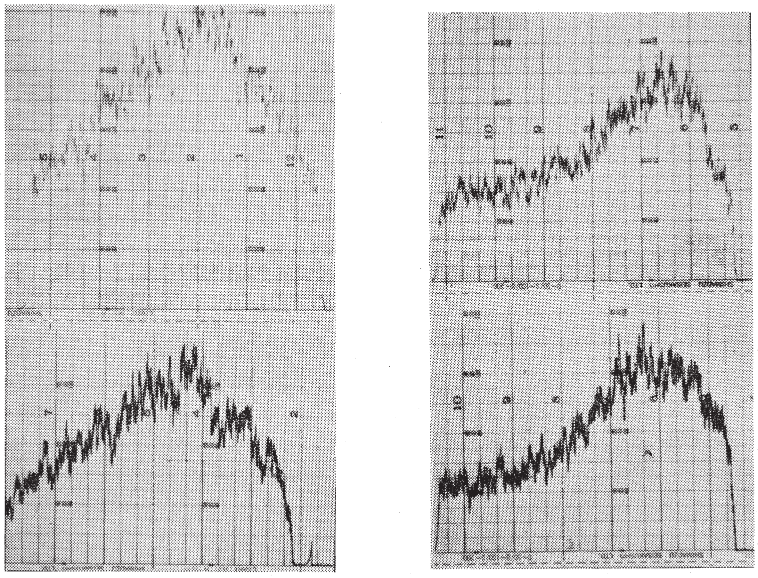


FIG. 15. Renograms of bilateral 2nd grade movable kidney.
(Upper: Right kidney Lower: Left kidney)

c) Renogram of Bilateral 3rd Grade Movable Kidney

Renograms at sitting posture in the 7 cases were investigated and obtained results as follows: (Table 1 and Fig. 12, 13, 16)

Mean values of right renogram;

$T_A = 29$ sec. $C_A = 299$ C.P.S. $T_B = 6$ min. 08 sec. $C_B = 684$ C.P.S.

$T_H =$ more than 15 min. $C_C = 430$ C.P.S.

$R_a = 2.32$ $K = 1.41$ $E = 39.6\%$

Mean values of left renogram;

$T_A = 26$ sec. $C_A = 335$ C.P.S. $T_B = 5$ min. 33 sec. $C_B = 736$ C.P.S.

$T_H =$ more than 15 min. $C_c = 396$ C.P.S.

$R_a = 2.26$ $K = 1.57$ $E = 46.0\%$

In the bilateral 3rd grade movable kidney, the excretory phase was markedly prolonged, A and B was lesser than normal value in some cases.

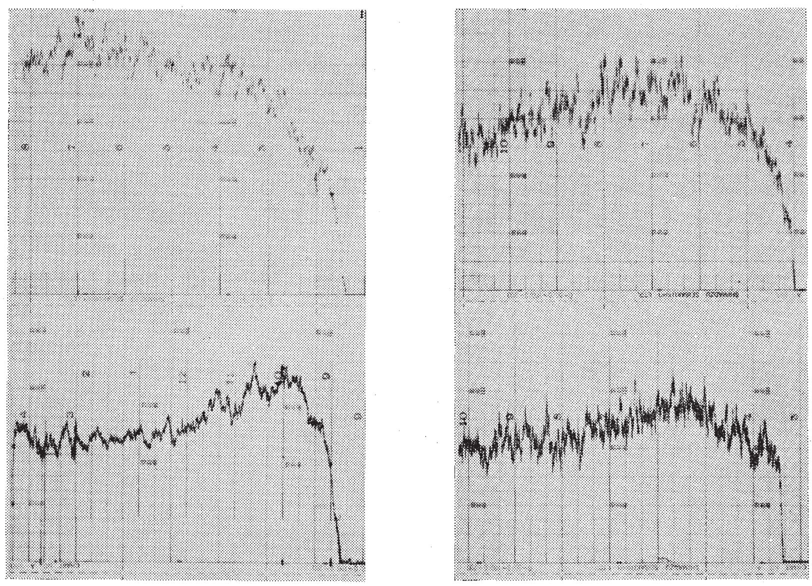


FIG. 16. Renograms of bilateral 3rd grade movable kidney.
(Upper: Right kidney Lower: Left kidney)

6) Difference of Renogram at Sitting and Supine Posture in Movable Kidney

In movable kidney, the ureter may be folded by the descent of the kidney. It may disturb the urinary flow and in the serious or long durated cases, dilatation of the pelvic or calyces may occur secondarily. Excreme elongation and angulation of the renal vessels may result from the variation of renal vascularity or secretory phase. In order to study these problems, renograms at sitting and supine posture in the movable kidney were taken and described the 10 cases that showed specific curves. Generally speaking, disturbance of the excretion was observed at erect renogram in the movable kidney, but contrarily it is often experienced that normal renogram at erect posture and specific renogram at supine posture in spite of existence of nephroptosis.

a) The Cases had Variations at Sitting Renogram

Case 1: 2nd grade right movable kidney (Fig. 17)

R_a, K and E showed 2.16, 1.35 and 55.6% respectively at sitting posture and 1.85, 1.53 and 71.4% respectively at supine posture. It means that normal renogram at supine posture but slight diminution of C_A and C_B γ-ray activity and excretory disturbance at sitting posture.

Case 2: 2nd grade left movable kidney (Fig. 18)

Generally declined γ ray activity and marked excretoy disturbance (E= 45.7%) were observed at sitting renogram. At supine posture T_H delayed a little (518 sec.), but it showed the curve almost similar to the normal.

Case 3: 2nd grade left movable kidney (Fig. 19)

E showed 55.0% at sitting renogram and 66.7% at supine renogram. Excretory disturbance was observed at sitting posture but lesser at supine posture.

Case 4: 2nd grade right movable kidney. (Fig. 20)

Decline of the γ-ray activity was observed both at supine and sitting posture in this case. K, R_a and E showed 0.46, 1.21 and 57.2% respectively at sitting posture. It means the diminution of the secretory function and excretory disturbance. But R_a, K and E showed normal value at supine posture.

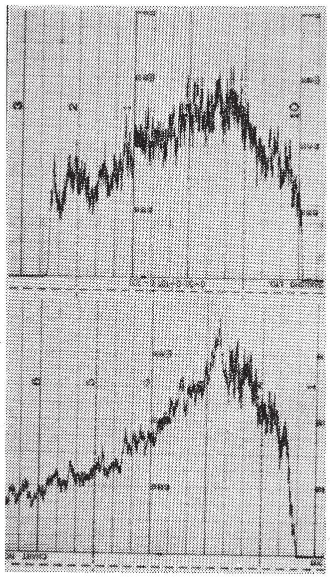


FIG. 17. Case 1, 2nd grade right movable kidney.
Upper: Erect posture.
Lower: Supine posture.

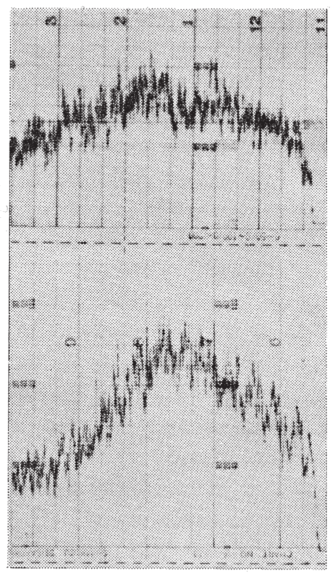


FIG. 18. Case 2, 2nd grade left movable kidney.
Upper: Erect posture.
Lower: Supine posture.

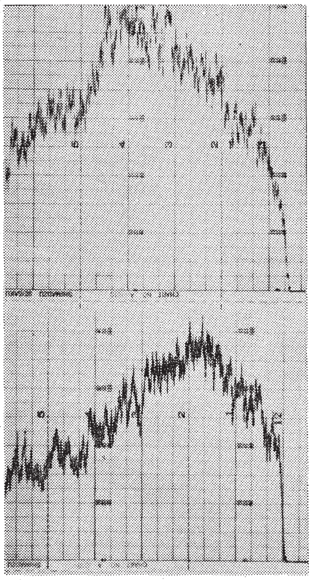


FIG. 19. Case 3, 2nd grade left movable kidney.
Upper: Erect posture.
Lower: Supine posture.

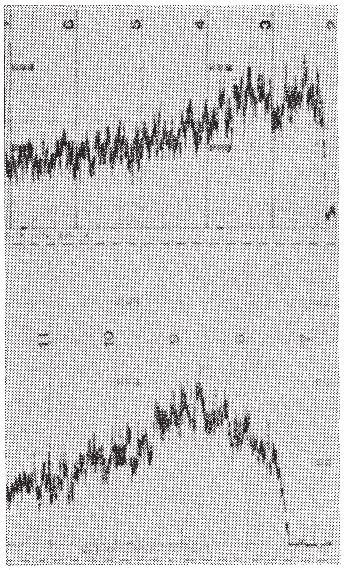


FIG. 20. Case 4, 2nd grade right movable kidney.
Upper: Erect posture.
Lower: Supine posture.

b) The Cases had Variations at Supine Posture

Case 5: 2nd grade right movable kidney. (Fig. 21)

R_a, K and γ-ray activity showed within normal limit as sitting renogram, but prolonged T_H (630 sec.) and excretory disturbance (E=68.8%) were observed at supine renogram.

Case 6: 2nd grade right movable kidney (Fig. 22)

Normal renogram was observed at sitting posture and prolonged T_H and low K (0.57) at supine posture. In this case accummulation of hippuran at secretory phase was noticed, but hippuran began to excrete rapidly after 8 min. 30 sec. of injection and E showed 71.7%. This renogram showed extremely specific type as Fig. 22 shown.

Case 7: 2nd grade right movable kidney (Fig. 23)

This case showed slight disturbance of renal function (E=46.7%, K=0.80) at sitting posture, and showed a specific renogram, rapid excretion after marked accummulation at supine posture as case 6.

Case 8: 2nd grade right movable kidney. (Fig. 24)

Excretory disturbance (E=53.8%) was observed at sitting posture and it revealed much more at supine posture.

Case 9: 3rd grade right movable kidney (Fig. 25)

Prolonged T_H and slightly low E (65.4%) were observed at sitting posture. K, E and T_H showed 0.57, 60% and 750 sec respectively at supine posture. Renal function at supine posture was much more disturbed than that at sitting

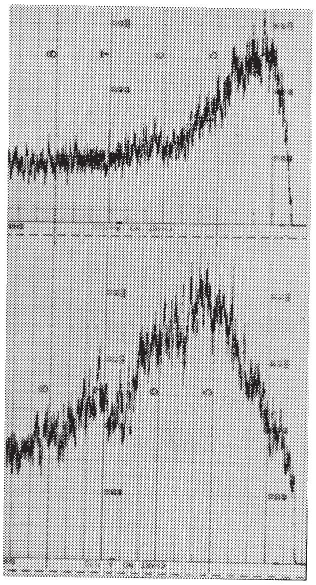


FIG. 21. Case 5, 2nd grade right movable kidney.
Upper: Erect posture.
Lower: Supine posture.

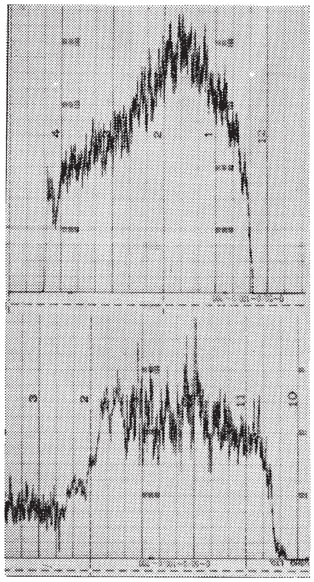


FIG. 22. Case 6, 2nd grade right movable kidney.
Upper: Erect posture.
Lower: Supine posture.

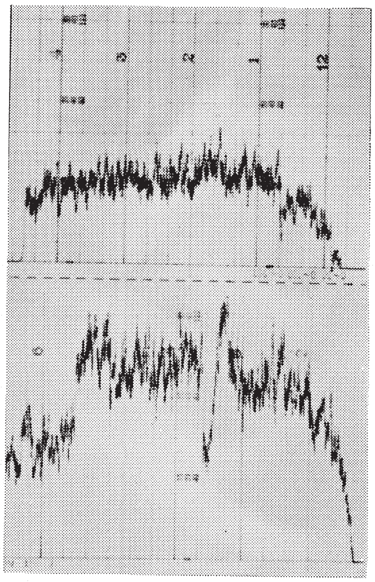


FIG. 23. Case 7, 2nd grade right movable kidney.
Upper: Erect posture.
Lower: Supine posture.

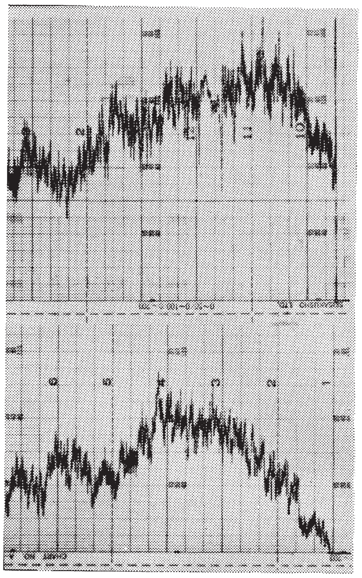


FIG. 24. Case 8, 2nd grade right movable kidney.
Upper: Erect posture.
Lower: Supine posture.

posture in this case.

Case 10: Bilateral 3rd grade movable kidney (Fig. 26, 27)

Variation of the renogram of this case was not in proportion to the ptotic condition of the kidney shown on intravenous pyelogram at erect posture. Right kidney descended more than left kidney, but the value of K and E of right renogram ($K = 1.36$, $E = 42.5\%$) showed higher than that of left renogram ($K = 0.49$, $E = 25.0\%$). When pressed the lower abdomen at supine posture, accummulation of hippuran was observed bilaterally. If taking the pressure away from the lower abdomen, γ-ray activity diminished temporarily and then increased again. This means the excretory disturbance. Dilatation of right pelvis and dilatation of left calyces were seen at supine intravenous pyelogram in this case.

As mentioned, above the specific renograms were obtained in the non organic changed 2nd grade movable kidney at sitting or supine posture. Renogram is usually taken at sitting posture. So if abnormal renogram were ob-

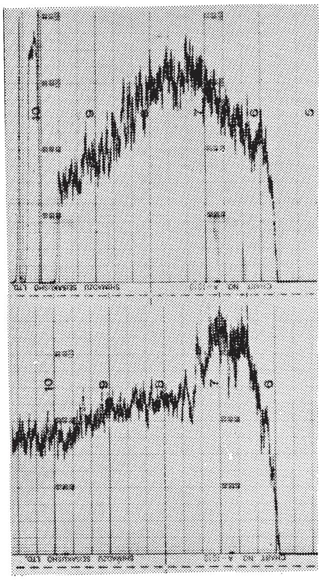


FIG. 25. Case 9, 3rd grade right movable kidney.
Upper: Erect posture.
Lower: Supine posture.

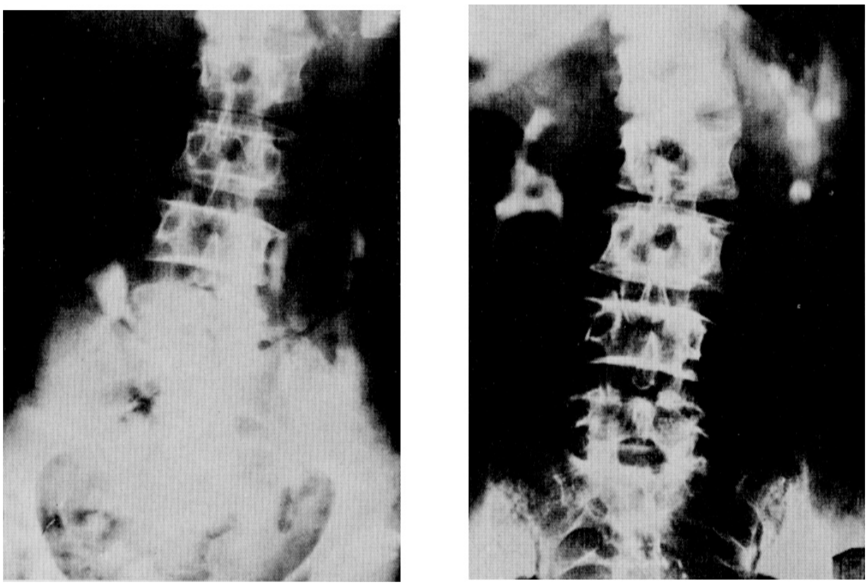


FIG. 26. Case 10, Bilateral 3rd grade movable kidney.
Right: Erect pyelogram. Left: Supine pyelogram.

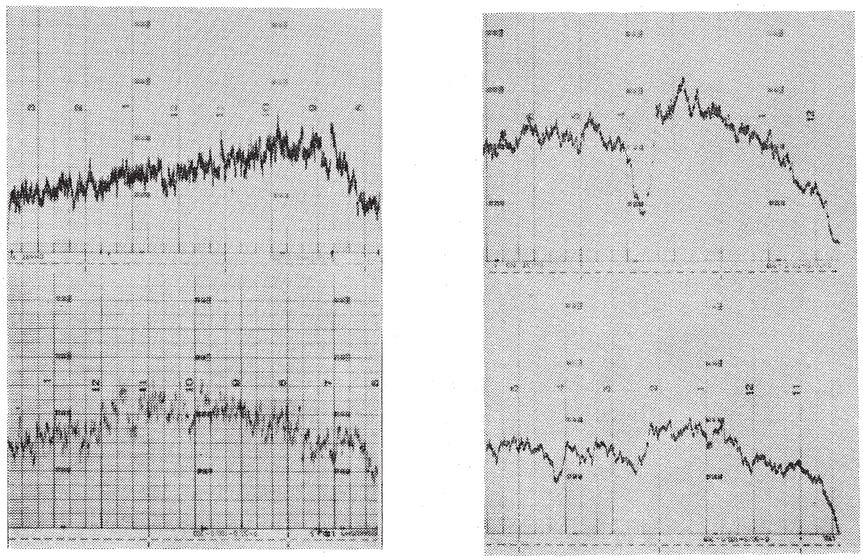


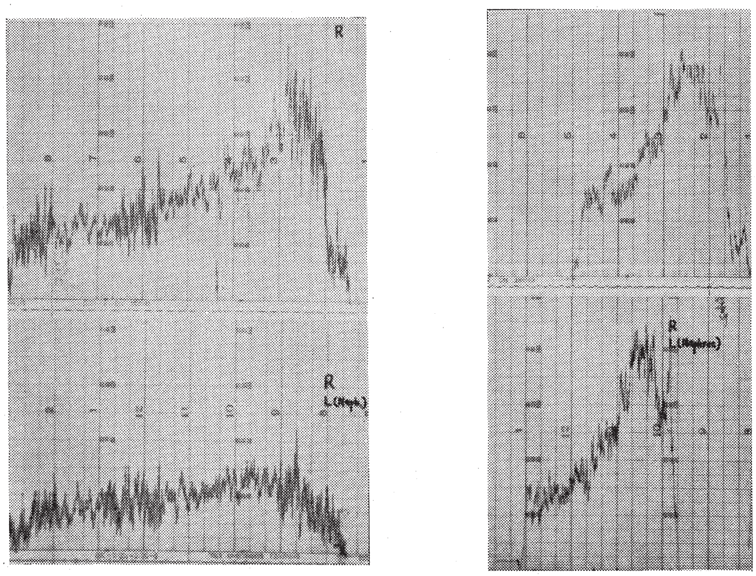
FIG. 27. Case 10, Bilateral 3rd grade movable kidney.
Right upper: Right kidney at sitting posture.
Left upper: Right kidney at supine posture.
Right lower: Left kidney at sitting posture.
Left lower: Left kidney at supine posture.

tained in spite of the negative urological finding, it is necessary to determine the exact position of the kidney by moving the detector, to take the renogram again at supine posture or for further study at another day. In the case of renal disease associated with any organic change, existence of the movable kidney should be determined ahead. If so, it is necessary to consider the variation of the renogram by the movable kidney, and then renal function should be determined.

In the case of movable kidney, abnormal renogram was obtained with the projected detector to the back, normal renogram was acquired by the projection of detector towards ventral side. (Fig. 28) It means the detector takes right angle to the ventral side of the kidney, the upper pole of the ptotic kidney bows towards the ventral side. In the normal kidney, the similar normal renograms were obtained either projecting the detector to the back or ventral side. (Fig. 28)

7) *Indication of Nephropexy and Postoperative Renogram*

In the case of 2nd grade movable kidney, C_A, C_B, R_a and K showed within normal limit, but prolonged T_H and low E and C_C were observed in 64%, 58% and 46% respectively out of 50 cases of bilateral movable kidney, and 55%, 45% and 35% respectively out of 20 cases of left 1st to 2nd grade movable kidney. In the case of 3rd grade movable kidney, low C_A, C_B, E, C_C and prolonged T_H were observed in all cases. (Table 1)



a b

FIG. 28. In the case of movable kidney, abnormal renogram was obtained with the projected detector to the back, normal renogram was acquired by the projection of detector towards ventral side.

a. Movable kidney.

b. Normal.

(Upper: Ventral Lower: Back)

Indication of the nephropexy in the movable kidney should be determined by the above mentioned results considered with patient's complaints and urological findings. The 2nd grade movable kidney with subjective symptomes, positive urological finding and abnormal T_H, E and C_U in the renogram may be an indication of nephropexy. In the case of 3rd grade movable kidney, the nephropexy should be advised whether the patient has complaints or not. (Fig. 12, 13)

The renogram after nephropexy showed almost normal in the patient, who has no hydronephrotic change more than 3 months after nephropexy. The variation of renograms were investigated each 2 to 4 weeks after nephropexy. Renogram 2 weeks after nephropexy in the 2nd grade right movable kidney (Fig. 29 A) showed similar to that of preoperative renogram, but renogram 3 weeks after nephropexy in the 2nd grade right movable kidney (Fig. 29 B) showed improvement of the secretory and excretory phase and renogram 4 weeks after nephropexy (Fig. 29 C, D) showed almost normal. It is presumed that renogram of the movable kidney may be improved to normal 4 weeks after nephropexy. We usually advise the patients absolute bed rest for 3 weeks after nephropexy. This period may adequate for the patient's recovery from the study of the renogram.

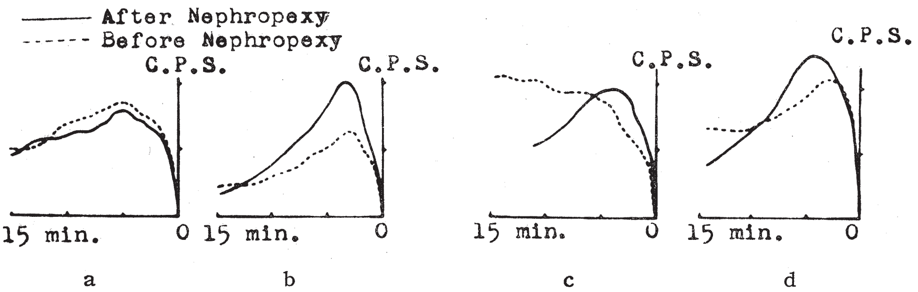


FIG. 29. Variation of renogram, in the case 2 to 4 weeks after nephropexy.
a. Two weeks after nephropexy in 2nd grade right movable kidney.
b. Three weeks after nephropexy in 2nd grade right movable kidney.
c. Four weeks after nephropexy in 3rd grade right movable kidney.
d. Four weeks after nephropexy in 3rd grade left movable kidney.

DISCUSSION

In 1956, Winter[1] reported radioactive diodrast renogram as a new renal function test and applicated it to the diagnosis of unilateral renal disorders and hypertension. In 1958, Winter and Taplin[4] used radioactive diodrast, miokon and urokon to take renogram and found that the diodrast is excreted rapidly from renal cells and is a most safe material for renogram test.

In 1960. Tubis, Posnick and Nordyke[5] reported that the diodrast is not a specific substance to the kidney, it is also absorbed to the liver. Hypaque, renografin, urokon and miokon are not absorbed to the liver, but have an extremely low clearance activity in the kidney. He also reported that the sodium o-iodohippurate (radio-hippuran), cleared rapidly from the kidney, is a most adequate material for a separate renal function test comparing with other isotope reagent and descrived the method of the preparation of the labelled hippuran.

In 1960, Nordyke, Tubis and Blahd[6] reported that only 0.04% of the hippuran was absorbed into the gall bladder in 20 minutes. In 1961, Meade and Shy[2] also described that 0.018% of the hippuran was demonstrated in 15 cc of the gall juice after one hour, and 0.16% was demonstreted in 440 cc of the gall juice after 24 hours.

In our study it was proved that the hippuran had a little influence to the liver and thyroid gland. We projected the detector to the left nephrectomized part and liver part to take radiohippuran renogram in the left nephrectomized patient and found that there had a little γ-ray activity. And we also projected the detector to the thyroid gland, which had affinity to the iodine, and found low γ-ray activity on the thyroid gland, the γ-ray activity disappeared 24 hours later as Meade and Shy[2] descibed.

In 1961, Meade and Shy[2] described the variations of the human renograms using radiohippuran under the various conditions. They showed the average renogram of the 78 cases of normal human and pointed out the value of right renogram are higher than that of left renogram in γ-ray activity, it may be due to the blood circulation in the liver.

In our study of 20 cases of normal human the similar results were obtained in both sides.

It is necessary to measure the renogram under the invariable condition for the analysis of the renogram. The dosis of the hippuran should be injected 0.4 μc per kg and about 500 cc of water intake 30 minutes before the test would be advisable.

In order to determine the renogram finding, it is important to decide the normal limit of the renogram as a standard. Although functional disturbance of the kidney may be infered from the renogram curve, we determined the following values as a normal limit of the renogram: $C_A > 300$ C.P.S., 100 sec $< T_B \leqslant 360$ sec., $C_B \geqslant 550$ C.P.S., $T_H \leqslant 522$ sec, $C_C \leqslant 250$ C.P.S., $R_a \geqslant 1.50$, $K \geqslant 1.0$, $E \geqslant 70\%$.

While Meade and Shy[2] reported that the renogram is a very excellent test for the renal function screening, 67.7±5.8% of the injected hippuran may be excreted to the urine after 30 minutes.

In our study of 10 cases, average 62% of the hippuran was excreted after 30 minutes. It is better than the 57% excretion of the diodrast done by Winter and his co-worker. In order to study the renal excretion clinically, E was calculated in stead of the urinary content of the hippuran after 30 minutes. Urinary excretion of the hippuran after 12 hours was 95.7%, so it is thought the renogram test may be a most safe and repeatedly examinable method for renal function test.

In 1960, Schwartz and Madeloff[7] found that there were no difference between PAH clearance and renogram test. They calculated the γ-ray activity of the A in the bilateral renogram and used their ratio to diagnose the renal function.

Dtermination of the position of the kidney is a most important matter to diagnose the movable kidney by the renogram. In 1956, Taplin, Meredith, Kade and Winter[8] determined them by the pyelogram. In 1960, Nordyk and his co-worker determined them by the hippuran injection. This method was suggested by Frohlich, Fedor and Freis[9] in 1959. Nowadays, Meade and Shy use this method as a routine examination, they determine the position of the kidney with small dose of the hippuran injection.

We also take this method to determine the position of the kidney. In the 18 cases out of 42 cases of the movable kidney, position of the kidney in the erect intravenous pyelogram corresponded to the position of the projected detector. It means that the renal position of the kidney descended lower than that of the erect intravenous pyelogram in the more than half cases. It was also proved by the animal experiment that γ-ray activity diminished 60% if moved the detector 5 cm laterally. It shows that how important the determination of the position of the kidney is.

In the renogram under 2nd grade movable kidney, mild to moderate excretory disturbance was observed, but the renal vascularity and secretory phase showed almost normal. In the 3rd grade movable kidney, decline of the γ-ray activity was observed in some cases. This may be due to the inclination or rotation of the kidney, extreme prolongation or angulation of the renal artery and partial organic change of the kidney. In the animal experiments, γ-ray activity diminished 19% if inclined the kidney 45 degrees laterally to the detector, and diminished 23.3% if inclined 90 degrees.

In 1961, Franklin and Meade[10] diagnosed the bilateral pelvic kidneys with renogram which showed very specific curve. To study the renogram of the renal inclination, the normal renogram was obtained with the projection of the detector from ventral side, in this case low γ-ray activity was observed with the projection of the detector from back. In the normal kidney, the renogram showed without any change either projected the detector to the ventral side or back. It is necessary to take the renogram with the projection of the detector to the ventral side in the case of the movable kidney associated with some organic change.

Meade and Shy reported the variations of the renogram by the patient's posture. And in 1961, Bauer and Feine[11] described the renograms at erect and supine posture by the radiourografin.

In our study of the renograms at sitting and supine posture in the movable kidney, generally the renogram at supine posture showed almost similar to that of normal kidney at supine posture, but renogram at sitting posture showed excretory disturbance in most cases compared with normal sitting renogram. But excretory disturbance was observed in some cases at supine posture, in these cases some cases showed normal renogram at sitting posture. In 2 cases shown in Fig. 22, 23, renogram showed that excretory disturbance appeared previously at supine posture and pelvic accummulated hippuran excreted rapidly a few minutes later. In the 3rd grade movable kidney, low γ-ray activity and excretory disturbance were observed both at sitting and supine posture, and mild organic change was associated with in some cases in intravenous pyelogram.

Generally, when one takes the renogram in the case of renal disorder, complication of the movable kidney should be studied previously. If so the renogram at sitting and supine posture or projected the detector to the ventral side should be taken and the variation of the renogram due to the displacement of the kidney should be strictly differentiated with that of disturbed renal function due to the organic change. Diagnosis of the movable kidney may be done easily by the situation of the detector projected.

The case with marked excretory disturbance in the renogram, severe subjective symptoms and remarkable change in the pyelogram in the 1st to 2nd grade movable kidney may be an indication of nephropexy. In the 3rd grade movable kidney, the nephropexy should be advisable whether the patient has a subjective symtoms or not. Up to now, the nephropexy were performed in more than 300 cases of the movable kidney. The renogram of them, passed more than 3 months after the nephropexy, showed almost normal and situation of the kidney fixed to the upper part of the incised wound.

In the cases with excretory disturbance, the renogram were returned to normal during the 3 to 4 weeks after nephropexy, so the nephropexy may be an adequate operation for the movable kidney especially with excretory disturbance and 3 weeks absolute bed rest after nephropexy may be necessary for fixation of the kidney and the recovery of the renal function.

Renogram test was performed more than 300 times and no side effects were found. It is used as a safe method for renal function test because of mild distress than the other urological examination for the patient and excretion of the hippuran in short time.

It is easy to determine the separate renal function, so that the renogram examination may be an essential test for the urological diseases, but it has to pay an attention to the existence of the movable kidney and determination of the situation of the kidney prior to the examination.

SUMMARY

Radiohippuran renogram test was performed in the 20 cases of the normal kidney and 42 cases of the movable kidney. Normal limit of the renogram was determined by our plan, then variation of the renogram due to the body weight, posture, water intake, influence of the surrounding organs and inclination of the kidney were studied. Human intra renal diminution ratio was calculated and applicated clinically in stead of the contents of the urinary excretion after 30 minutes of the injection.

In the movable kidney to the 2nd grade, renal vascularity and secretory phase had no remarkable change but in the 3rd grade movable kidney they decreased. Excretory phase had mild to moderate excretory disturbance in the movable kidney to the 2nd grade and extremely marked in the 3rd grade movable kidney. Nephropexy should be performed in the case had excretory disturbance, and renogram may return to normal about 3 weeks after nephropexy.

In the renal disorder associated with the organic change, existence of the movable kidney should be examined, if so sitting and supine renogram and renogram with projected the detector to the ventral side were taken and variation of the renogram due to the movable kidney should be corrected. Diagnosis of the movable kidney may be easily done by the position of the detector projected.

Radiohippuran renogram examination gives not only a little distress to the patient, but also can determine the separate renal function simultaneously. It is very safe and useful method for the renal function test. It should be paid an attention to determine the situation of the kidney.

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