SCANNING ISOTOPE RENOGRAM

Yoichiro Umegaki M.D.*
Fumiko Nakanishi M.D.**
Yoshio Sakamoto M.D.**

走査式レノグラム法

（国立がんセンター放射線部）
梅垣洋一郎
（信州大学医学部放射線医学教室）
中西文子
坂本良雄

（昭和38年2月6日受付）

現在腎機能検査法として用いられているアイソトープレノグラム法には種々の欠点があるので，これを改良した走査式レノグラム法を考案した．本置装の特長は次の諸点である．

1）アイソトープの時間的空間的分布を同時に記録分析し得る．

2）本装置のために特殊コリメータを製作した．これにより腎の位置，深さによる誤差を極少とし，測定結果をより定量的とした．

3）従来使用せられているシンチスキャナーを利用して簡単に安価に製作し得る．

So-called isotope renogram has established its superiority in the study of renal function. It can estimate the function of each kidney independently at the same time. It does not require to collect urines or bloods, and takes only less than half an hour. At present, however, it has many points to be improved. First of all the result is not quantitative. Unless the results of certain clinical tests become quantitative, we can not fully rely on them. disadvantage of the current renogram set may be summarized as follows.

1) It requires to combine a couple of scintillation detector, rate meter and recorder into one set. Each of them needs to have exactly equal characteristics.

2) Collimation and positioning are most impotant in the procedure of renogram. Many factors have influences on the quantitativeness and repeatability. Individual variation in the position of kidney makes difficult to catch them with narrower collimators. On the other hand, wider collimator cannot discriminate counts from the opposite kidney and body background. On account of these sereous difficulties, ordinary renogram set fails to realize a quantitative diagnosis.

3) The sensitivity and spectral characteristics of each sintillation counter must be maintained throughout the measurement. However the changes in sensitivity due to the

* Department of Radiology, National Cancer Center Hospital
** Department of Radiology Shinshu University Medcial school

Fig. 1. Scanning equipment used for isotope renogram.

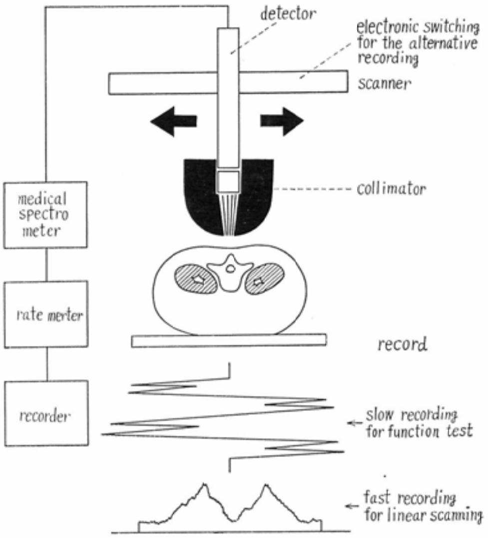

Fig. 2. A schematic diagram of the equipment used for a scanning isotope renogram

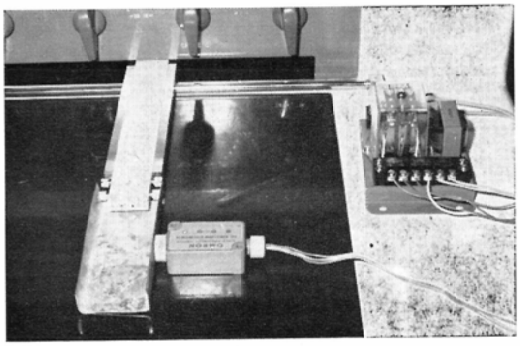

Fig. 3. The electronic switching device for the alternative recording of both kidneys.

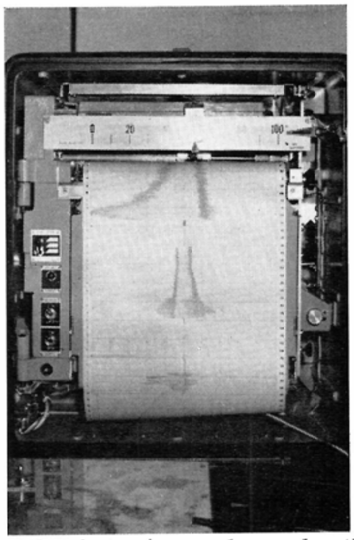

Fig. 4. The electronic recorder used as the slow recorder.

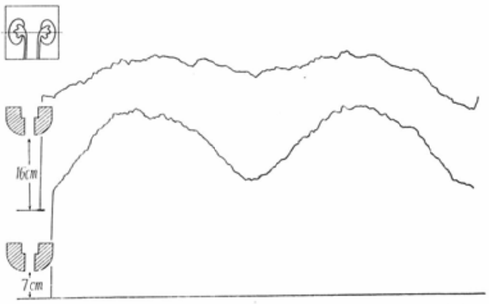

Fig. 5. Scanning over the model kidneys with cylindrical collimator

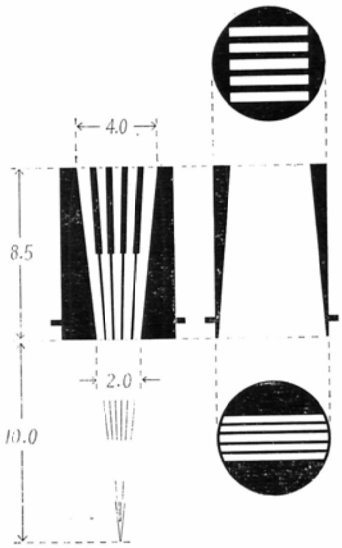

Fig. 6. Schematic diagram of the focussing collimator designend in our laboratory F=10cm

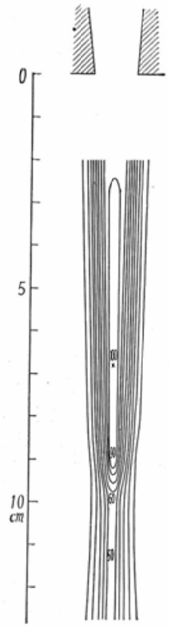

Fig. 7. Isoresponse curves of focussing collimator (transverse axis)

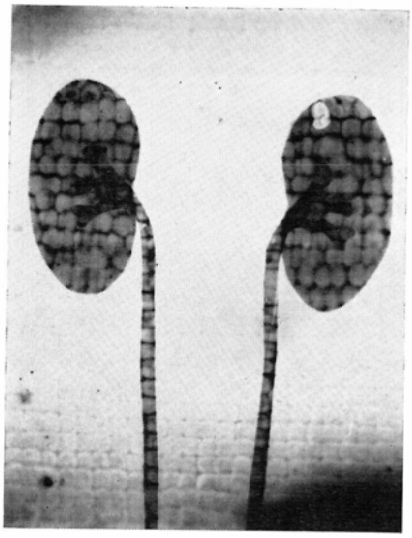

Fig. 9. Autoradiograph of the model kidneys
Concentration of I^{131}

renal pelvis	0.6 $\mu c/cm^2$
renal parenchyma	0.2 $\mu c/cm^2$
body background	0.02 $\mu c/cm^2$

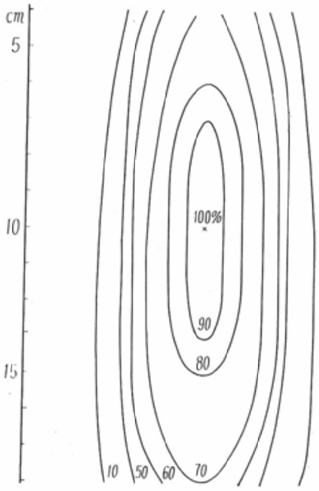

Fig. 8. Isoresponse curves of focussing collimator (longitudinal axis)

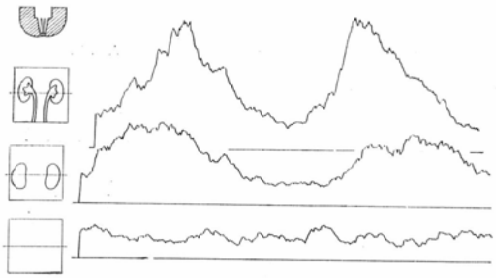

Fig. 10. Scanning over the model kidneys with focussing collimator

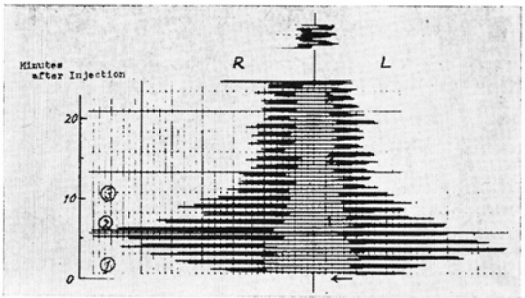

Fig. 11. Case 1 normal kidney

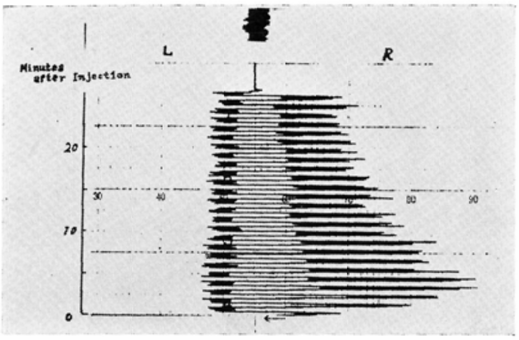

Fig. 12. Case 2. Irradiation nephritis of the right kidney ? The left kidney was removed under a diagnosis of the malignant tumor

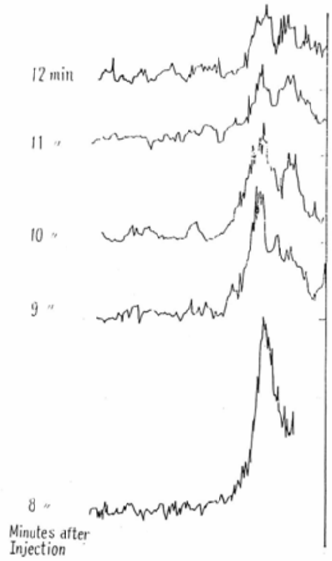

Fig. 14

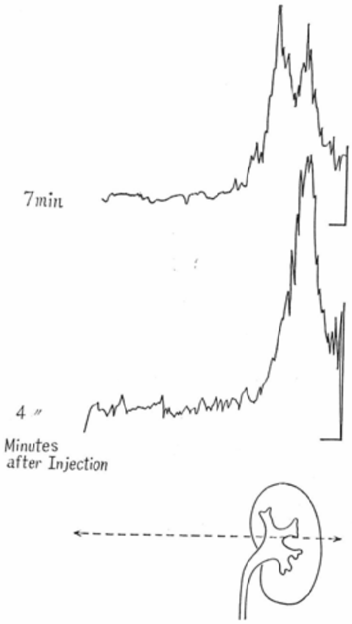

Fig. 13. Case 2. Linear scanning of the Kidneys in transversal direction

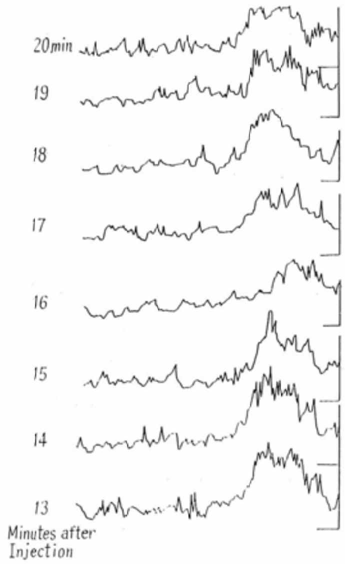

Fig. 15

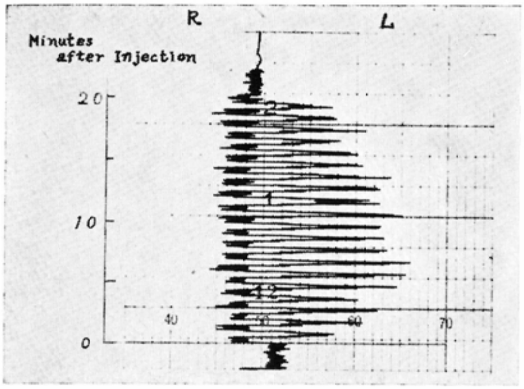

Fig. 16. Case 3. Hydronephrosis of both kidneys

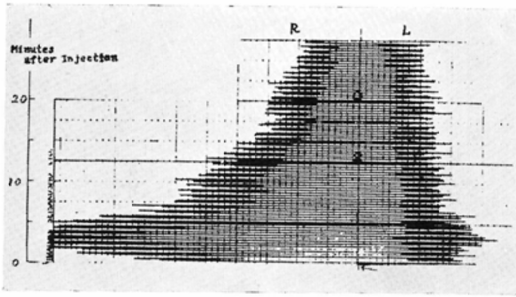

Fig. 17. Case 4. Hydronephrosis of the left kidney

fluctuation of power supply and etc. do not appear equally in both of them.

4) So-called renogram with the ordinary method shows only the sum of counts from blood flow, body background, renal parenchyma. renal pelvis and ureter. It is too dfficult and meaningless to analyse it quantitatively.

To aquire useful informations from linear scannings of kidney, the collimator must be designed to have a good resolution. Ordinary cylindrical collimators used in renogram are inadequate for this purpose. On account of their broad collimating angle, they cannot discriminate even counts from the opposite kidney. Fig. 5.

We designed and made a focussing collimator. The structure and isoresponse curve shows the narrow collimation in transverse axis and the broad collimation in longitudinal axis. The narrow collimation is very important to improve the resolution of linear scanning and to discriminate background counts. Broad collimation in longitudinal axis is useful to avoid errors due to malpositioning of kidney.

In order to demonstrate the benefits of this collimater, a couple of model kidney was made and measured with our scanning renogram. This model kidney is made up of renal parenchyma, pelvis ureter and body background. Each component is made of filter papers soaked with proper coocentration of ^{131}I. Fig. 10 and 5 shows the results of linear scanning done on this model kidney using the focussing collimater or not. Linear scan with the focussing collimater can discriminate each component clearly. Contrary to it the scan with the cylindrical cone fails to discriminate. Moreover the response of cylindrical cone is highly dependent on the geometrical conditions. This uncertainty in response is one of the cause of unquantitativeness. On the other hand, evidcntly from the isoresponse curve, the distance is not critical in the scanning with focussing collimater.

Recently an improved type of renogram was deviced in our laboratory, This method has solved almost all problems mensioned above.

Method and material

The essential point of our method is the repetition of linear transverse scanning of both kidneys. The scanning is done with a combination of only one detecter and the specially designed focussing collimater. Since the detecter is only one, the problem of balancing disappear. An area scanner was modified for this purpose but to only a little extent. The recording system is a combination of fast and slow ones. The fast recorder describe the linear scanning or the spatial distribution of ^{131}I hippuran through the scanning plane. For this purpose, X-Y recorder is the most adequate one. Repeated linear scan be arranged in order holding exactly same co-ordinate. These series of scans are very useful to observe the spacial distribution or movement of RI. The slow recorder describe the uptake and excretion by each kidney separately but in one paper. Using a simple electronic non-contact relay the recording is divided into two sections. During the scanning of right half of body, the counting rate is recorded on the right half of the recorder, and is reversed during the scanning of the other half. The envelope lines in both side are tracing automatically the peak values of renal activity. The discontinuity of the recording seems to be the loss of datas however, the adequate scanning speed can minimize it.

Results

Case 1. 38 years old male. Clinical diagnosis: carcinoma of rectum. His rectum was resected 3 years ago. Recently he is suffering from the incontinentia urinae and the sacral pain. Radiologic examination revealed a metastatic lesion on his sacrum. This was treated with telecobalt irradiation. No pathological change was found in the standard urological examinations.

The renogram is shown in Fig. 11. Both curves are symmetrical and show quite normal uptake-excretion curves.

Case 2. 56 years old male. He was admitted to our hospital with a symptom of hematuria. His left kidney was removed under the diagnosis of malignant tumor. Following this operation he had a course of of X-ray therapy. Afterward he was found to have a slight albuminuria. Isotopic renogram was tried to examine the function of the residual kidney.

The results is shown in Fig. 12. The right side curve corresponding to the function of the right side kidney shows a reduced vascular phase, slow secretary and excretory phase. The hypofunction is evipent compared to case 1 but the extent of it is not so marked. The left side curve shows the absence of kidney or non-functioning kiney.

Fig. 13, Fig. 14 and Fig. 15 show the linear scannings carried out simultaneously. In these scannings the spatial distributions RI and its changes after the injection. At first the curves show single peaks corresponding to the vascular phase in the renal parenchyma. Then the second peak appears and grows up. This corresponds to the activity of the urine excreted intoh the renal pelvis and the ureter. Thus we can analyze the renal function in two dimensions.

Case 3. 35 years old male. He was admitted to our hospital with a chief complaint of dysuria. Clinical diagnosis is the hydronephrosis of both side kidney due to the strictura uretrae.

The renogram of left side shows a reduced vascular phase, an abnormally slow secretary phase and a slowly descending excretory phase. This means the hypofunction of left kidney due to the hydronephrosis. The renogram of right side shows only a vascular phase and means the non-functioning kidney. Intravenous pyelography showed a marked hydronephrosis in left side and failed to visualize the right side kidney. The results of phenol sulphon phthalein test was as follows.

30	min.	0%
1	hrs.	5%
2	hrs.	10%
3	hrs.	17%
4	hrs.	10%
5	hrs.	8%
Total		50%

Case 4. 59 years old male. He was admitted to our hospital with symptoms of hematuria and dysuria. Cystoscopic examinations revealed a carcinoma of urinary bladder. Intraveneous pyelography failed to show the excretion from his left kidney. The renogram shows the absence of function in the left side. This condition may be caused by the ureteral obstruction due to the infiltration of carcinoma. The right side shows normal functioning kidney.

Summary

1) Much improved quantitativeness in the isotope renogram is obtained with our scanning renogram method.

2) The details of construction are described.

3) Spatial and temporal scanning can be done at the same with our method.

4) 4 cases are presented.