portion.

The excretion process is given as

$$V_{ue} \cdot C_{ui}(t) = \int [(RPF)_i \cdot C_p(t) - F_i \cdot C_{ui}(t)]dt, \quad i = R \text{ or } L \qquad (2)$$

where V =the equivalent volume of urinary tract, F =urine flow rate, and C =urinary concentration.

A renogram record $r_i(t)$ is given as

$$r_i(t) = k[\int (RPF)_i \cdot C_p(t)dt - \int F_i \cdot C_{ui}(t-\tau_i)dt + (\text{background})_i] \qquad (3)$$

where k=a proportional constant, τ=transportation lag time. Urinary excretion is represented by the following equations:

$$e(t) = eR(t) + e_L(t)$$
$$e_i(t) = \int F_i \cdot C_{ui}(t-\tau_i)dt \qquad (4)$$

The backgroud is

$$(\text{backgroud})_i = b_i \cdot V_{pe}(t) \cdot C_p(t) \qquad (5)$$

To enable an estimate of renal plasma flow rate in each kidney on ^{131}I-Hippuran renograms, and glomerular filtration rate on ^{131}I-sodium iothalamate renograms to be made, a special purpose analog computer was designed based on equations (1) to (5), equipped with input of 100V equivalent to the total amount of injected isotope, and output of four curves, r (t) (renogram curves, equation (3), right and left) and e (t) (excretion curves, equation (4), right and left) to simulate measured renogram records as well as measured urinary excretion rate. When there is a good agreement between the renogram records and the computer results obtained on a recorder, and concurrently, between the measured percentile excretion in the urine and the computer results obtained, total and individual renal plasma flow rate or glomerular filtration rate, V_{ui}/F_i (time constant of the excretory system), τ (time delay) and b_i (background) can be read from the set values of potentiometers in the simulator. Those renogram-computer-derived RPF's or GFR's were compared to PAH clearance or TS clearance values measured on the same subject at different occasions.

In 17 patients, 2 with normal kidneys, 13 with unilateral, 1 with bilateral renal diseases, 1 with essential hypertension, 18 direct measurements of individual renal plasma flow rate by standard PAH clearance method with unilateral ureteral catheterization technique were performed, and right to left ratios of CPAH were comparable to that of renogram-gram-computer-derived RPF's (r=0.97). This result shows that when the renogram curves and the urinary percentile excretion are known, renal plasma flow rate in each kidney can be estimated with accuracy comparable to that of the conventional cumbersome clearance procedure, which is a steady-state observation in equation (2) in the mathematical model. In 19 subjects, renogram-computer-derived GFR's were compared to TS clearance values (single shot method) with a close correlation (r =0.95).

In this model, the renal exceretory process was simulated by a first-order diffusion process with a pure delay time. The close coincidence between the results obtained from the model and the clinical findings suggests that the modelffi might be sufficient, in spite of its simplicity, to describe he dynamic renal excreory process observed in renogram records.

A Study on the Kidney Dynamics from the Standpoint of Clinical Radioisotope Laboratory

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As far as the radioisotop technique is concerned, renography is, at present, most frequently applied to the renal function study. There have been many approaches to analyze the patterns of renograms in their details. However, the renogram pattern obtained on the recorder is always influenced by many factors such as type of collimator used, ori-

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entation of the probe and postural difference etc. From this reason, we do not apply mathematical analysis on the renograms obtained as a routine work.

When external counting is done in the radioisotope laboratory as a routine test, it is necessary to be easy to perform. Therefore, we are using sitting position for the renography.

If positioning of the probe is incorrect, segment B is most influenced, resulting in lowering the peak height.

In sitting position, segment B is sometimes shown as an almost flat curve though the posiioning of the probe is perfectly correct. In such case, the curve of the drainage is alwayss normal. If such a patient lies on his stomach and the probe is positioned from his back, another performance of the renography will give normal curve. These phnomena are observed mostly in the right kidney. We consider that this fact is probably due to the anatomical situation of the righ kidney.

In sitting position, hydronephrotic pattern (no drainage) is sometimes observed in patients who has no organic obstruction through the urinary tract. In such case, changing the posture, such as standing and walking several steps, will show sudden evacuation on the renogram, resulting in normal drainage curve. If the obstructive pattern does not show any change, then organic obstruction may be present. From the above-mentioned several facts, we think that there are, at present, many restricions in quantitative analysis of the renogram.

When quantitative measurement is necessary we take two blood samples with heparinized syringes at 5 and 20 minutes after the injection during the renography, followed by a complete collection of urine at 30 minutes as acccurate as possible. Thhen, one ml of plasma from each blood sample is counted and plotted on the semi-logarithmic paper. A straight line is drawn through these two points and 15 minutes count (P) is obtained from it. Also one ml of urine is counted. Our easy method gives $RPF_{Hippuran}$ as follows:

$$RPF_{Hippuran}=\frac{U\times V}{P}\times\frac{1}{30}$$

where, U is the count of one ml of urine sample and V is the total urine volume. $RPF_{Hippuran}$ is found to be in a good correlation with RPF_{PAH} which is obtained by the conventional PAH clearance method.

Recently, ^{131}I-sodium iothalamate (^{131}I-Glofil) is commercially supplied, which is said to reflect the glomerular filtration rate (GFR). GFR_{Glofil} obtained by the same method as in the determination of $RPF_{Hippuran}$ was found reasonable in our experiments.

It is well known that the Hippuran-renograms of the kidneys with diffuse parenchymal damage have definitely different patterns from those of normal ones. However, there were not so much differences between Glofil-renograms of the normal kidneys and those of the abnormal ones having diffuse parenchymal damage in our results obtained. Therefore, there may be a difficulty of using ^{131}I-Glofil as a test agent for reuography but it can be used for the determination of GFR by counting the plasma and urine samples.

As a conclusion, we think that the double tracer method (^{131}I-Hippuran and ^{125}I-Glofil) will be recommended as a clinical procedure because one injection can give $RPF_{Hippuran}$ and GFR_{Glofil} in one performance and furthermore usual renogram with ^{131}I-Hippuran also can be obtained during this test.

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