

Measurement of Residual Urine Volume with a 16-in. Gamma Camera Interfaced to a PDP 11/45 Digital Computer

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A procedure has been developed using an intravenous injection of 50 μ Ci of ^{131}I -sodium iodohippurate to measure a renogram and residual urine volume using a scintillation camera interfaced with a PDP 11/45 digital computer. Residual urine is measured 2 hr after injection. The external counting method using a probe for measurement of residual urine has been shown by many investigators to be the most accurate method without catheterization. The scintillation camera method described here for determination of residual urine has many advantages over the probe counting method and is more accurate.

Urine that is retained in the bladder as a consequence of incomplete voiding predisposes to urinary-tract infection. A residual pool of urine also makes treatment of the infection difficult and increases the possibility of reinfection. At times there is a reluctance or a contraindication to the use of a catheter simply to determine the quantity of residual urine. Therefore a number of simple and inexpensive methods have been developed to measure the volume of residual urine without catheterization (1-5). Of these methods the radionuclide external counting procedure is the most accurate (5, 6). We have developed a method for external counting using a scintillation camera interfaced with a PDP 11/45 digital computer.

Materials and Methods

Ten drops of Lugol's solution are given by mouth immediately before a dose of 50 μ Ci of ^{131}I -sodium iodohippurate is injected intravenously. The patient lies supine on a Stryker nuclear medicine stretcher with the head raised about 15 deg. (If a Stryker stretcher is not available, the sitting or

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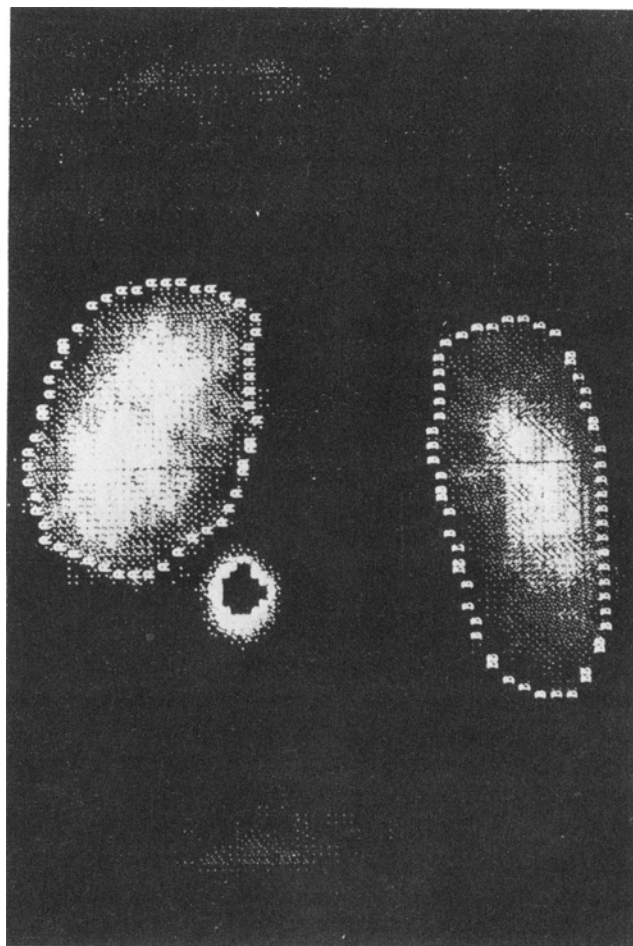


FIG. 1. Series of letters, A and B, circumscribing kidneys demonstrate areas of interest over both kidneys.

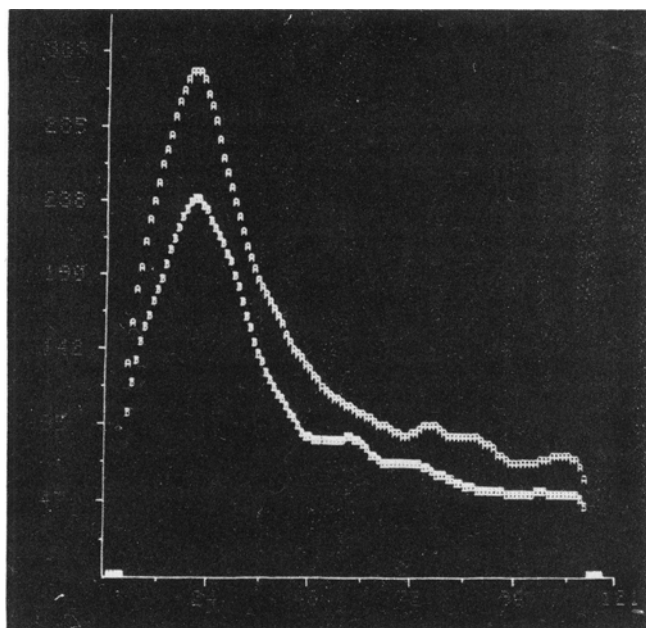


FIG. 2. Renogram with 5-point smoothing.

semi-reclining position is recommended.) Counts are recorded by a PDP 11/45 digital computer at a rate of one frame every 10 sec for 20 min. A renogram is constructed by outlining each kidney within a region of interest. The counting rate as a function of time is plotted, and the curves are smoothed by a 5-point smoothing program (Figs. 1 and 2). Two hours after injection the patient lies supine on an imaging table under the scintillation camera with the camera detector head raised to its maximum

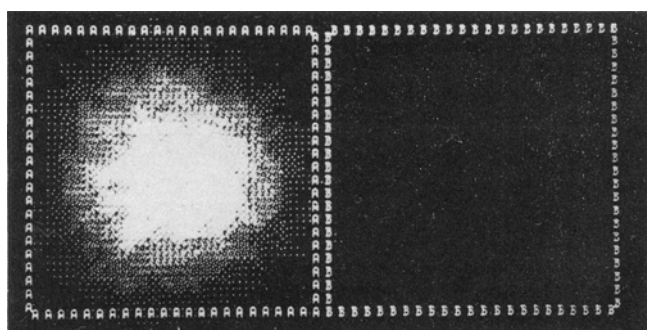


FIG. 3. Pre-void count.

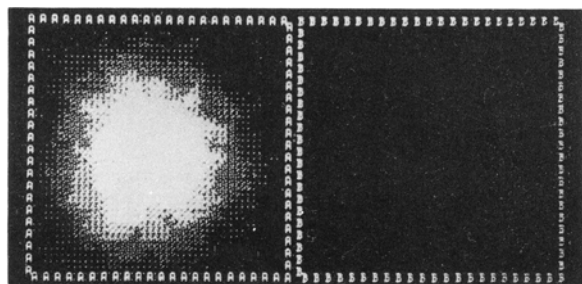


FIG. 4. Post-void count.

height (approximately 38 cm between table top and collimator face). A 4-min pre-void count is taken. Without moving, the patient voids immediately and a 4-min post-void count is taken as soon as urination is completed. All the information is recorded in the PDP 11/45 digital computer. Using equal areas of interest, pre-void, post-void, and background counts over region of umbilicus are obtained (6) (Figs. 3-5). The volume of urine is measured. A Bard Cunningham incontinence clamp is used on the men patients to ensure that there is no urine leakage pre- and post-void. (There is no suitable device for women patients.) An artery forceps is used if the patient has an indwelling catheter.

Calculations

The difference between the pre- and post-void counting rates over the bladder is the voided radioactivity. This quantity divided by the voided volume provides the concentration. From the residual radioactivity in the bladder, the residual volume in milliliters can be calculated (3).

The formula is as follows:

$$\text{Residual urine (ml)} = \frac{V(C_2 - bg)}{C_1 - C_2},$$

in which V is the amount of urine voided in ml, C_1 is pre-void bladder counts, C_2 is post-void bladder counts, and bg is bladder background.

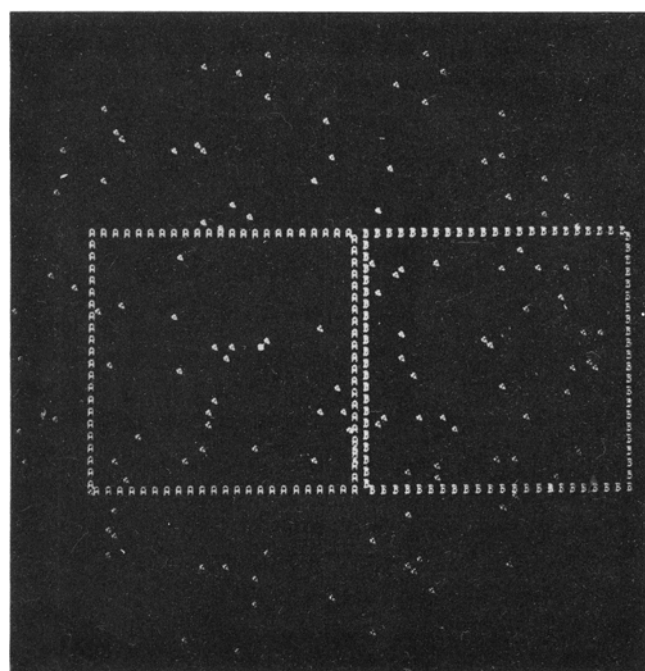


FIG. 5. Complete voiding after drainage from indwelling catheter.

Example. Step voiding on a patient with indwelling catheter:

$$\text{Residual urine after first voiding} = \frac{104 (10,670 - 833)}{12,965 - 10,670} = 445 \text{ ml.}$$

$$\text{Residual urine after second voiding} = \frac{420 (306 - 283)}{10,670 - 306} = 0.85 \text{ ml.}$$

The patient from whom the above data were taken had an indwelling catheter so that a direct measurement of residual volume was possible. The measured volume was 420 ml compared with 445 ml determined by the isotopic technique. Therefore, the isotopic method gave a result that was 6% higher than the true volume.

Since such sources of error as imperfect positioning of the collimator, limited field of view for large distended bladders, bladder background, and inflow of radionuclide between pre-voiding and post-voiding count (4-6) are minimized by use of this method, the author undertook an experiment to determine sources of error other than the statistical and instrumental errors. This was done by putting 10 μCi ^{131}I -hippuran into a 500-ml spherical flask, adding 50 ml water, and counting using the same geometry as for a patient residual urine determination. After the first 50 ml of solution had been counted, additional 50-ml aliquots of water were added and counted until a volume of 500 ml was reached. The results showed that there was a 5% decrease in counting rate for each 100 ml water added. This can be explained by self-absorption or attenuation of radiation in the solution. Since this error is less than 5% and decreases with the volume of fluid, corrections for it were not made.

Results

The scintillation camera method has the following advantages over the probe counting method:

1. A renogram is obtained to assess kidney function.
2. There is no error in positioning because the patient is not moved during micturition and the field of view of the scintillation camera is large (16 in.).
3. Background count can be obtained simultaneously with bladder count since the field of view of the scintillation camera is large.
4. The actual distribution of the radionuclide is visualized, and by comparing the pre-void and post-void images one can estimate the volume of the residual urine with added confidence of the accuracy of the results obtained.
5. The time required between pre-void and post-void counting using this method is very short (normally 1-3 min); therefore there is no concern about the inflow of radioactivity into the bladder in that period.

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