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Received July 22, 1968. P.S.E.B.M., 1968, Vol. 129.

Catheterization of Renal Artery in Rats* (33462)

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This paper describes a modification, for use in rats, of the method of Rudolph *et al.* (1) for chronic catheterization of the renal artery in dogs.

Design of catheter. The renal artery catheter is made by stretching a heated polyethylene tubing (PE10) to an outside diameter of about 0.009 in. A length of 3–4 mm of the thinned part forms the tip of the catheter. Three small ridges are made on the unstretched part of the tubing, one at the beginning of the taper to give it a pear shape and others at different distances from it; these are used to anchor the catheter (Fig. 1). The total length of the catheter is 25 cm. The PE10 tubing is heated by holding it inside a nichrome wire loop the temperature of which is adjusted by a powerstat. When the part of the tubing inside the loop starts softening it can be stretched or compressed to make the taper or the ridges, respectively, while the powerstat is momentarily turned off.

Catheterization of the renal artery. Female rats of the Holtzman strain (204–290 g) were operated on under ether anesthesia and aseptic conditions. The animal is laid on its right flank. The skin is incised about 5 mm lateral and parallel to the left spinal muscle mass, and the abdominal aorta and the origin of the left renal artery are exposed retroperitoneally. A "O" thread is passed loosely around the aorta between the origins of the two renal arteries (Fig. 2). A stitch (6 "O") is then tied into the adventitia of the aorta about 1 mm medial to the origin of the left renal artery with ends left long to be used to secure the catheter in place. The adventitia of the renal artery is grasped and held still, and the artery wall is pierced close to its origin with a 27-gauge needle while the blood flow in the aorta is arrested by pulling the "O" thread. The needle is withdrawn, and traction on the "O" thread is slowly reduced until a drop of blood appears at the puncture site. The tip of the catheter (filled with heparin in saline and connected at the distal end by a needle to a stopcock and syringe) is inserted into the artery and the grasp on the artery released. Blood flows into the catheter upon further release of traction on the aorta; the blood is reinjected and the stopcock is closed. The catheter is secured by tying the 6 "O" thread around it above the pear shaped tip. The stopcock is then opened and blood permitted to flow out to make sure small clots are not obstructing the catheter. The catheter is then refilled with fresh heparin solution and sealed by tying off its distal end.

The catheter is secured further by sutures in the abdominal muscle fascia tied around its other ridges; then it is brought under the skin to a stab wound in the back of the neck where it is coiled under the skin and the sealed end tied to the wound. The abdominal wound is closed.

The aortic blood flow should not be arrested longer than 3–4 min at a time. If the catheter cannot be introduced at the first attempt, the aortic flow is released slowly

* This work was supported by Grant No. AM-01588 from the National Institute of Arthritis and Metabolic Diseases of the United States Public Health Service.

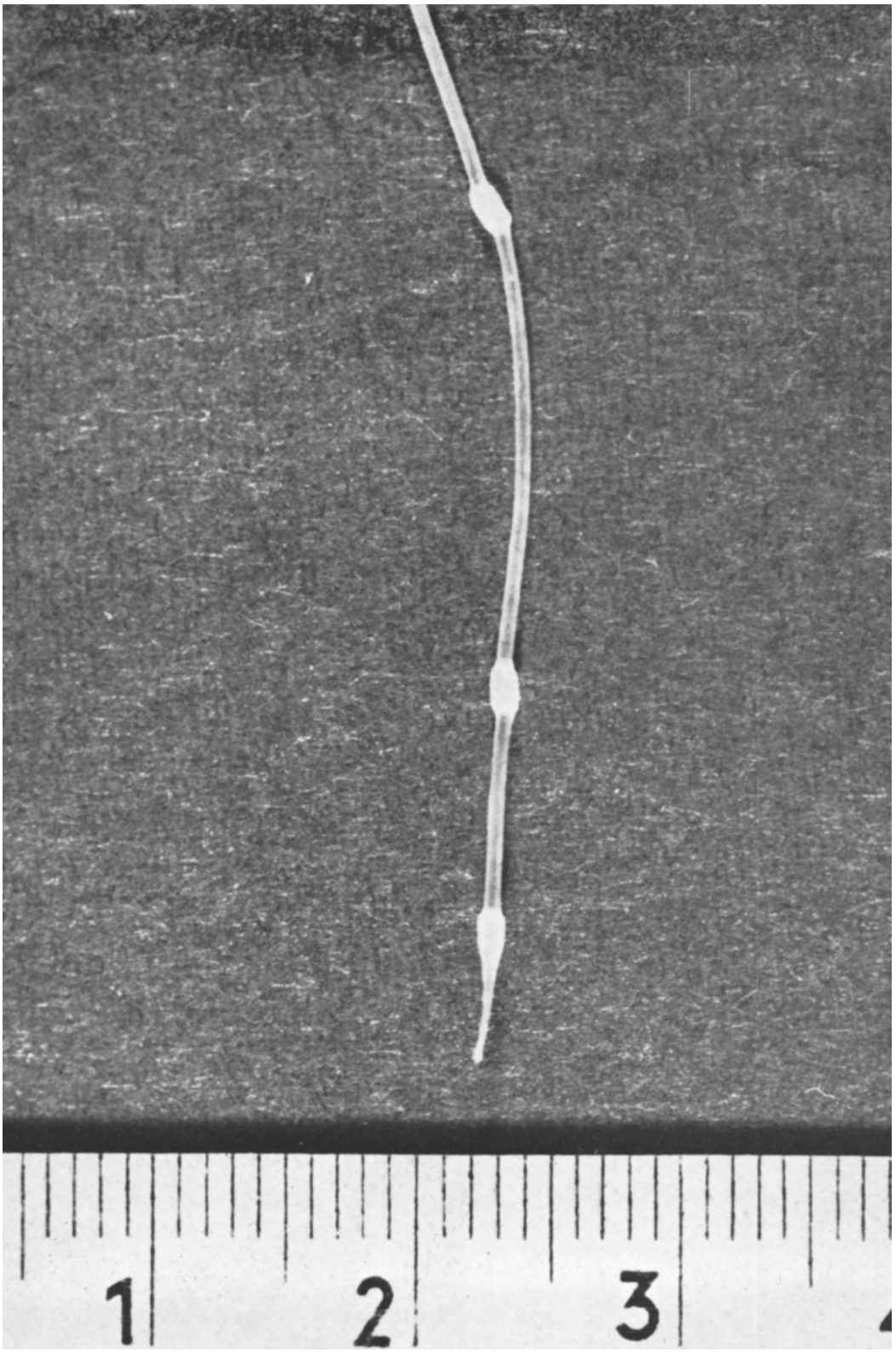

FIG. 1. Photograph of renal artery catheter. The small divisions of the scale indicate millimeters.

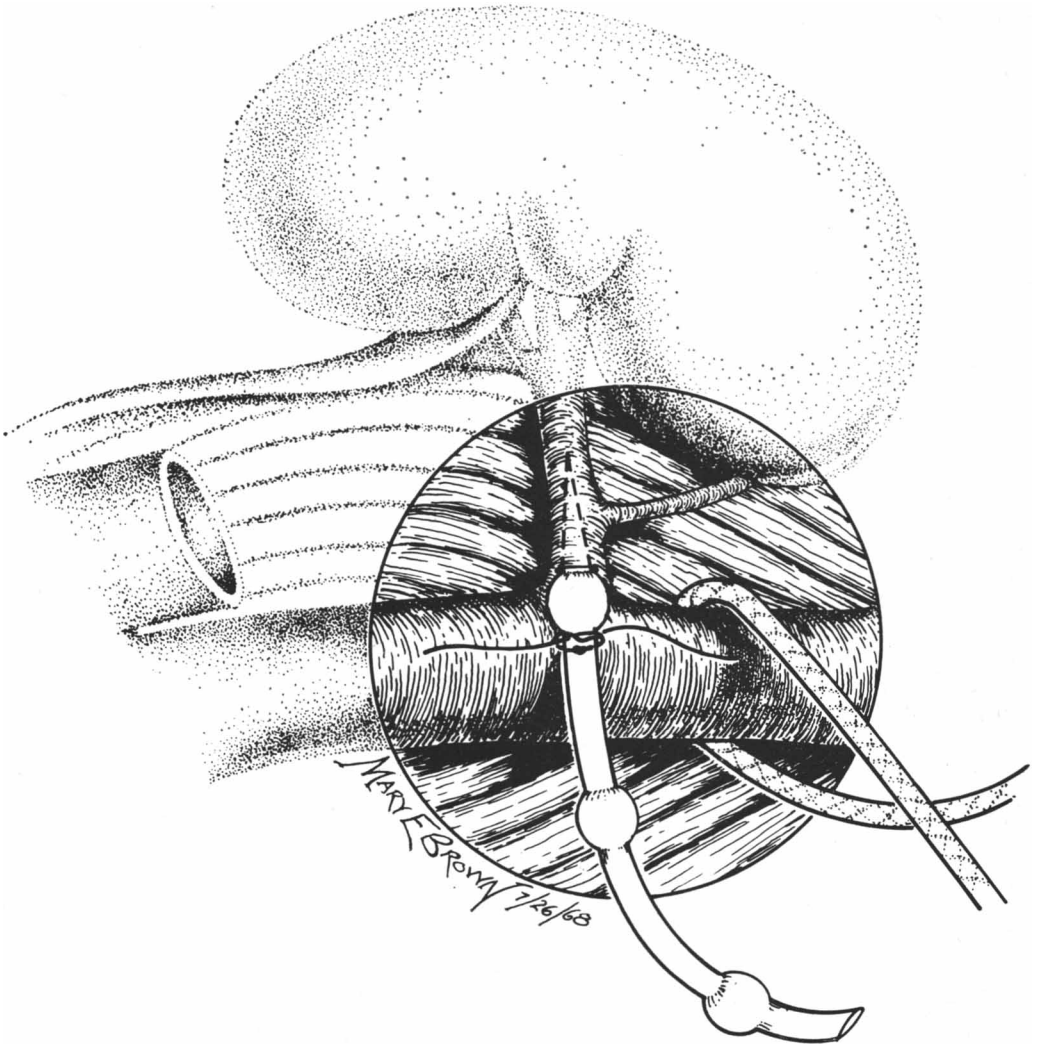

FIG. 2. Diagram showing catheter in position in left renal artery.

enough to allow clotting at the puncture site. About 10 min later another attempt can be made by introducing the catheter tip through the clot while the aortic flow is only partially occluded.

In the present experiments most of the rats were used 18 hr after catheterization. The catheter can be kept patent for longer periods (48 hr in one of these rats) by flushing it twice daily with heparin solution (10 U/ml of 0.9% saline), but there is increasing likelihood of clotting at the tip.

Analytical methods. Urinary *p*-aminohippurate (PAH) was determined by the method of Smith *et al.* (2) and urinary endogenous creatinine by the method of Phillips (3).

Evaluation of function of the catheterized kidney. The functional condition of the catheterized left kidney was evaluated by comparison with that of the undisturbed right kidney. The rats were anesthetized and hydrated to 5–7% of body weight by means of a 12% solution (v/v) of ethanol in water given by stomach tube. Hydration and anesthesia were maintained by 2% ethanol given repeatedly in volumes equal to the urine output during the interval between doses. When the animal was adequately anesthetized, the ureters were catheterized (by way of a midline

TABLE I. Glomerular and Tubular Excretory Functions in Kidney with Catheterized Renal Artery (left) Relative to Those in Undisturbed Kidney (right).

Rat no.	Body wt. (g)	No. of peripheral venous infusions	Endogenous creatinine excretion: left/right[a]		PAH excretion: left/right[b]		Creatinine (left/right) / PAH (left/right)	
			Mean	Range	Mean	Range	Mean	Range
1	254	3	0.66	0.64–0.67	—[c]			
2	240	4	0.88	0.83–0.92	0.97	0.90–1.05	0.92	0.84–0.96
3	220	6	0.68	0.53–0.80	0.71	0.60–0.86	0.97	0.88–1.16
4	240	1	0.64		0.85		0.75	
5	210	4	0.95	0.88–1.09	0.80	0.71–0.84	1.20	1.07–1.51
6	218	3	0.62	0.56–0.95	0.72	0.56–0.95	0.89	0.68–1.00
7	205	4	0.88	0.83–0.94	0.94	0.88–1.00	0.94	0.94–0.96
8	210	3	1.00	0.96–1.03	1.07	1.00–1.13	0.94	0.85–1.03
9	215	3	0.81	0.75–0.88	0.86	0.80–0.90	0.95	0.93–0.98
10	218	4	0.89	0.76–1.02	1.04	0.95–1.24	0.86	0.75–1.07
11	206	4	0.92	0.88–1.03	1.02	0.91–1.15	0.91	0.84–1.00
12	209	3	1.09	1.01–1.15	1.07	0.94–1.25	1.02	0.88–1.22
13	204	4	0.84	0.77–0.95	0.80	0.67–0.89	1.06	0.86–1.18
14	205	5	0.97	0.92–1.02	0.99	0.83–1.07	0.99	0.86–1.16
15	238	2	1.09	1.08–1.09	1.16	1.12–1.19	0.94	0.92–0.96
16	245	3	1.06	1.03–1.12	1.25	1.13–1.37	0.85	0.82–0.92
17	228	3	0.83	0.80–0.86	0.95	0.90–1.00	0.87	0.80–0.96
18[d]	290	3	0.58(0.65)	0.56–0.59	0.63(0.68)	0.58–0.67	0.91(0.96)	0.86–1.02
19[d]	225	3	0.94(0.70)	0.71–1.05	1.12(0.96)	0.88–1.27	0.83(0.73)	0.81–0.86
20[d]	223	3	0.93(0.83)	0.91–0.98	1.05(0.91)	1.01–1.11	0.89(0.96)	0.88–0.90
21[d]	267	0	(0.35)		(0.50)		(0.71)	

[a] The means and ranges indicate the ratios of the amount of endogenous creatinine excreted by the left kidney relative to that concurrently excreted by the undisturbed right kidney from the beginning of each peripheral venous infusion to the beginning of the next infusion (usually via left renal artery).

[b] The means and ranges indicate the ratios of the amount of PAH excreted by the left kidney relative to that concurrently excreted by the right kidney during the same intervals as those in which creatinine excretion was measured.

[c] PAH determinations were unsatisfactory in this first animal of the series.

[d] In rats 18–20, clearances of PAH and exogenous creatinine were measured during a single 30-min period beginning 1 hr after the last infusion of vasopressin. In rat 21 only these clearances were measured. Values in parentheses represent the corresponding left/right ratios of these clearances.

suprapubic incision) with PE10 tubing inserted near their entrance into the bladder. If carefully done this operation is practically bloodless and usually will not prevent the development of satisfactory water diuresis. (Ureteral catheterization in advance, i.e., 18 hr or more before the experiment, was often followed by clogging of one or both of the ureteral catheters with development of hydroureter; sometimes the rat chewed off the protruding tips of these catheters, and retraction under the skin resulted.) A saphenous vein was then catheterized and connected to a needle, 3-way stopcock and syringe.

Table I shows the ratios of the excretion of endogenous creatinine and PAH by each kidney in 21 rats, prepared as described above, that were used in studies of the renal clearance of vasopressin (4) (complete manuscript in preparation). In these animals (except rat no. 21), 3-min infusions of physiological doses of vasopressin (total dose, 25–100 μU) were given at 30-min intervals alternately by way of the peripheral vein and the left renal artery. Included in each infusion was 0.2 mg of PAH, an amount calculated to produce plasma concentrations in the left renal artery (when it was given by that route) below that capable of saturating the tubular excretory mechanism. The amount of

PAH excreted by each kidney from the beginning of an infusion to the beginning of the next was measured.

Table I shows only the data related to the peripheral venous infusions: the number of such infusions given to each rat, the means and ranges of left/right ratios of excretions of creatinine and of PAH in each rat, and finally, the mean and range of the ratio of creatinine L/R divided by concurrent PAH L/R. On the assumption that the clearances of endogenous creatinine and of PAH are measures of glomerular filtration rate and effective renal plasma flow, respectively, the data of the last column, therefore, indicate the ratio of the filtration fraction in the left kidney to that in the right (the mean ± SD of these 65 ratios was 0.94 ± 0.13).

The overall average excretion of PAH (65 collections of urine) was 0.057 ± 0.011 (SD) mg in 30 min by the right (undisturbed) kidney and 0.052 ± 0.011 mg by the catheterized left kidney when 0.20 mg of PAH was infused into a peripheral vein at a constant rate during 3 min. The discrepancy (0.109 mg excreted of 0.20 mg infused) is due mainly to conjugation, the product of which is not measured by the method used (5). The overall average excretion of endogenous creatinine by the right kidney was 72.0 ± 19 μg in 30 min and 62.5 ± 11 μg in 30 min by the left kidney (2.4 and 2.1 μg/min, respectively).

Catheterization of the left renal artery was performed in a total of 33 rats. Of the 12 animals not included in Table I, 7 had no urine flow from the left ureter 18 hr or more after the arterial catheterization; the left kidney appeared necrotic under gross examination in all of these. In the remaining 5 rats, the left kidney functioned as well as the right kidney as judged from the similarity in urine flow through both ureters, but data could not be obtained because of difficulties during the experiment (in 2 rats the renal artery catheter clogged during the first injection; 1 rat went into sustained antidiuresis at the beginning; and 2 did not develop enough diuresis to permit carrying out the experiment).

Summary. A method is described for chronic catheterization of the left renal artery in female rats. Glomerular and tubular excretory functions of the cannulated kidney were evaluated 18–48 hr after catheterization by concurrent comparison of its excretions of endogenous creatinine and intravenously administered PAH with those of the undisturbed right kidney. The data show that both functions were satisfactorily preserved in the cannulated kidney.

Our thanks to Dr. Berl Bass for useful suggestions on the design of the catheter and to Miss May Mei and Messrs. Richard Grisberg and Matthew Rifkin for technical assistance.

Note added in proof: The same technique has recently been used successfully in our laboratory for the cannulation of the left renal artery in dogs. The modifications are that the 6 "O" stitch is tied directly into the adventitia of the left renal artery, that the "O" loop is placed around the renal artery proximal to the stitch instead of around the aorta, and that a PE50 tubing with only a beveled tip is inserted through a hole made with a 22-gauge needle.

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Received April 10, 1968. P.S.E.B.M., 1968, Vol. 129.