

# THE EFFECT ON THE KIDNEY OF BILATERAL SPLANCHNICECTOMY IN PATIENTS WITH HYPERTENSION

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Recently there has been a renewed interest in the etiology and treatment of hypertension (hypertensive vascular disease) and its relationship to the kidneys. A surgical method of treatment of hypertension which was devised by Peet (1) consists of a bilateral resectioning of the major and minor splanchnic nerves and of the lower dorsal sympathetic chain including the 10th, 11th and 12th ganglia, supradiaphragmatically. This procedure has been employed in a sufficient number of cases so that the trend of results is indicated. It is the purpose of this communication to report the effect of this operation upon the kidneys, as it is shown by measurement of renal function and urinary abnormalities, and to correlate this effect with the blood pressure changes. Considerations of the rationale behind this treatment of hypertension, selection of candidates, technical procedure, and results other than the renal effect will not be discussed.

## METHOD OF STUDY

Every candidate for this operation was carefully studied in order to exclude all cases having hypertension secondary to known organic disease. Special care was taken to exclude those patients with hemorrhagic (glomerular) nephritis having elevated blood pressure. As a result only cases considered to have primary ("arterial") hypertension (hypertensive vascular disease), were treated by splanchnicectomy. This report includes observations on only those patients whom we have studied over a period of three months, or longer, after operation.

Before, and at intervals after this operation, blood pressure and renal function were measured, and the urine was analyzed. The blood pressure was in every case measured with a mercury manometer several times while the patient was lying down. Renal function was measured by the urea clearance test of Van Slyke and Cope

(2) and by the Lashmet-Newburgh concentration test (3). Proteinuria was measured by sulphosalicylic acid precipitation (4), and the formed elements in the urinary sediment were counted by the Addis method (5).

*Criteria for classification.* We have adopted the normal values found by the originators of the tests of renal function, i.e., for the concentration test a nonprotein specific gravity of the urine of 1.029 or more, and for the urea clearance, values between 75 and 125 per cent of the mean normal. The renal function was considered to be impaired when the result of either of the functional tests was below normal. A significant change in renal function was considered to consist of a change in specific gravity of 0.003 or more, or a change of 15 per cent or more in urea clearance.

It is always difficult to discuss changes in blood pressure because of the fluctuations encountered. For the purpose of classification, we have grouped the patients according to the change in blood pressure following splanchnicectomy as follows: 1, those whose blood pressure was reduced to 160/100 mm. Hg, or less; 2, those whose blood pressures did not remain below 160/100, but whose systolic blood pressure was reduced more than 60 mm. Hg, or whose diastolic pressure was reduced more than 30 mm.; 3, those whose systolic blood pressure was reduced from 30 to 60 mm., or whose diastolic pressure was reduced 15 to 30 mm. Hg.

## RESULTS

By this method we have now studied forty-eight cases. The data on these cases are presented in Table I. A summary of the relationship between the renal status and the blood pressure will be found in Table II.

In almost every case there was a sharp fall in blood pressure to normal or below, immediately after splanchnicectomy. It then followed one of several courses: in some it remained approx-

TABLE I

Data on each of the 48 cases studied, showing pre- and postoperative renal activity and blood pressure

Case number and initials	Sex	Age at time of operation	Known duration of hypertension	Time of observation	Blood pressure	Concentrating ability of kidneys	Urea clearance	Urine		Classification in Table II	Remarks
								Proteinuria	Hematuria		
1 W. L.	M	29 years	9 mos.	Pre-op.	236/166	1.014	106	0.3	0	1Ab	
				2 wks. postop.	134/90	1.022	58	Trace	0		
				6 wks. postop.	140-160	1.026	80	0	0		
					100-116						
				5 mos. postop.	138/90	1.033	108	0	0		
				11 mos. postop.		1.033	125	0	0		
				15 mos. postop.	150/90						
				29 mos. postop.	156/100	1.031	95	0	0		
2 M. P.	F	41	5 yrs.	Pre-op.	205-240	1.024	59	Trace	0	1Ab	
					125-130						
				3 wks. postop.	120/80						
				3 mos. postop.	140-160		91	0	0		
3 J. J.	M	45	1½ yrs.	Pre-op.	190-230	1.028	71	0	0	1Ab	
					100-150						
				3 wks. postop.	148/96						
				6 mos. postop.	142-160						
4 V. E.	F	22	3 yrs.	Pre-op.	280/190	1.033	87	0.12	2.2	1Aa	
				2 wks. postop.	150/110						
				2 mos. postop.	146/102	1.025	38	Trace	0		
				5 mos. postop.	150/120	1.028	82	Sl. tr.	0		
5 P. D.	M	46	15 yrs.	Pre-op.	180-190					1Ac	Bladder residual at time of concentration test
					110-120	1.028	91	0	0		
				1 mo. postop.	140/90						
				4 mos. postop.	140/88	1.0255	92	0	0		
6 G. P.	F	23	2 yrs.	Pre-op.	248-270	1.026	80	Trace	0	1Ac	
					138						
				2 wks. postop.	180/120						
7 C. L.	M	35	7 mos.	Pre-op.	268/176	1.019	40	0.3	280	1Bb	
				2 wks. postop.	180/130	1.020	95	0.05	0		
				2½ mos. postop.	200/128	1.030	113	Trace	0		
				6 mos. postop.	190/130	1.030	85	Trace	0		
				9 mos. postop.	180/125	1.030	125	0	0		
				16 mos. postop.	180/140		98	0	0		
8 S. B.	M	53	4 yrs.	Pre-op.	230-260	1.023	70	0.1	3.7	1Bb	
					170-180						
				3 wks. postop.	125-130	1.022	51	Trace	0		
					90						
				5 mos. postop.	160-166	1.027	77	Trace	0		
					109						
				8 mos. postop.	160/110	1.026	83	Trace	0		
				10 mos. postop.	150-165						
					105-110						
				12 mos. postop.	145/100						
				14 mos. postop.	150	1.028	89	0	0		
					105-110						
				17 mos. postop.	148/110	1.030		0	0		

TABLE I—Continued

Case number and initials	Sex	Age at time of operation	Known duration of hypertension	Time of observation	Blood pressure	Concentrating ability of kidneys	Urea clearance	Urine		Classification in Table II	Remarks
								Proteinuria	Hematuria		
		years			mm. Hg	nonprotein specific gravity	per cent of mean normal	per cent	millions of r.b.c.'s per 12 hours		
9 E. G.	F	46	3 yrs.	Pre-op. 2 wks. postop. 6 mos. postop.	250/134 212/100 150/100	1.024 1.034	72 136	0.05 0	0 1.25	1Bb	
10 M. W.	F	44	3 yrs.	Pre-op. 2 wks. postop. 3 mos. postop. 6 mos. postop.	250-260 150-162 140/95 178-220 110-120 186-200 112	1.023 1.027 1.028	77 86 111	Trace 0 0	0 0 0	1Bb	
11 E. H.	F	23	6 yrs.	Pre-op. 2 wks. postop. 2 mos. postop. 6 mos. postop.	230-240 140-160 180/130 176/128 170/128	1.026 1.030 1.033	84 88 89	Trace Trace Trace	0 0 0	1Bb	
12 O. Mc.	M	44	6 mos.	Pre-op. 2 wks. postop. 2 mos. postop. 3 mos. postop. 6 mos. postop.	224-256 140-172 170 110-116 150/110 170/116 190/124	1.021 1.028 1.024	 84 97 120	Trace Trace Sl. tr.	5 0 1.3	1Bb	
13 A. B.	F	40	6 yrs.	Pre-op. 1 mo. postop. 6 mos. postop.	244-276 148-156 160/120 178/112	1.036	97 103	Trace 0	0 0	1Ba	
14 H. R.	F	49	2 yrs.	Pre-op. 3 wks. postop. 5 mos. postop. 9 mos. postop.	210-252 120-148 160/100 155/100 174/105	1.030 1.032 1.029	101	Trace 0 0	0 0	1Ba	
15 F. M.	M	38	1 yr.	Pre-op. 2 wks. postop. 5 mos. postop.	240-260 145-150 210/115 210 120-130	1.025 1.027 1.029	71 72 86	0.4 0.1 Trace	0 0 0	1Cb	
16 L. M.	M	31	4 yrs.	Pre-op. 2 wks. postop. 2 mos. postop. 6 mos. postop. 16 mos. postop.	220-226 145-158 140-150 90-100 190/140 180-200 134-140	1.024 1.026 1.026	56 72 60 92	Trace Trace Trace	0 0 0	1Cb	Acute coryza
17 S. O.	F	33	?	Pre-op. 3 wks. postop. 6 mos. postop.	210 130-140 130-160 70-110 170-198 110-126	1.026 1.029	59 81	Trace Trace	0	1Cb	

TABLE I—Continued

Case number and initials	Sex	Age at time of operation	Known duration of hypertension	Time of observation	Blood pressure	Concentrating ability of kidneys	Urea clearance	Urine		Classification in Table II	Remarks
								Proteinuria	Hematuria		
18 M. S.	F	33	2 yrs.	Pre-op.	mm. Hg 190-220	nonprotein specific gravity 1.028	per cent of mean normal 76	Trace	millions of r.b.c.'s per 18 hours 0	1Cb	
				3 wks. postop. 6 mos. postop.	94-130 154/116 140-220 84-108	1.033	92	Trace	0		
19 N. M.	F	39	3 yrs.	Pre-op.	198-260 138	1.016	56	2.0	Gross	1Cb	
				2 wks. postop. 4 mos. postop.	200/130 180-220 130	1.023	109	Trace	0		
20 H. F.	M	46	2 yrs.	Pre-op.	235-280 126-170	1.029	89	Trace	0	1Ca	
				3 wks. postop. 8 mos. postop.	195/130 220-240 149	1.029	78	Trace	0		
21 D. P.	M	41	7 yrs.	Pre-op.	234-250 150-160	1.025	88	Trace	0	1Cc	
				1 mo. postop. 10 mos. postop.	210/105 210/136	1.024	100	0	0		
22 E. C.	F	45	1½ yrs.	Pre-op.	198-244 114-140	1.026	96	0.1		1Cc	
				2 wks. postop. 3 mos. postop.	132/82 168/230	1.027	108	0			
				6 mos. postop.	100-130 180/110	1.028	122	Sl. tr.			
23 L. V.	F	33	4 yrs.	4 yrs. pre-op.	158/100	1.018		0		1Cc	? pituitary disease with diabetes insipidus
				3 yrs. pre-op.	158/112	1.016		Trace			
				2 yrs. pre-op.	182/130			Trace			
				1 wk. pre-op.	202/132	1.012	129	Trace	0		
				3 wks. postop. 10 mos. postop.	130/90 160 112-120	1.012	92	Trace	0		
24 L. B.	M	45	5 yrs.	Pre-op.	210-220 120	1.030	71	Sl. tr.		1Cd	
				3 wks. postop. 14 mos. postop.	150/95 180-190 110-130	1.025		Trace			
25 H. H.	F	44	3 yrs.	Pre-op.	240-248 154-165	1.033	75	Trace	0	2a	
				3 wks. postop.	200-240 140						
				4 mos. postop. 6 mos. postop.	235/130 226-250	1.029 1.032	76	Trace Trace	0 0		
				21 mos. postop.	132-142 242/148	1.034	80	Trace	0		
26 H. K.	M	37	3 yrs.	Pre-op.	190-226 130-160		80	Trace		2a	
				3 wks. postop. 8 mos. postop.	180/110 230/150		84	Trace			

TABLE I—Continued

Case number and initials	Sex	Age at time of operation	Known duration of hypertension	Time of observation	Blood pressure	Concentrating ability of kidneys	Urea clearance	Urine		Classification in Table II	Remarks
								Proteinuria	Hematuria		
		years			mm. Hg	nonprotein specific gravity	per cent of mean normal	per cent	millions of r.b.c.'s per 18 hours		
27 H. S.	M	36	8 mos.	Pre-op.	198-215	1.018	91	0	0	2d	
				3 mos. postop.	120-148 168-180 120	1.025	66	0.05	0		
				4 mos. postop.	186/110		74	Trace	0		
				6 mos. postop.	204/132						
				13 mos. postop.	200/128	1.024		Trace	0		
				24 mos. postop.	194-204 120-126						
28 T. A.	M	47	6 mos.	Pre-op.	185-204 135	1.017	83	Trace	0	2d	
				3 wks. postop.	170/140						
				9 mos. postop.	190/130	1.030	125	0	2.8		
29 F. N.	F	39	3 yrs.	Pre-op.	220-250 130-150	1.022	26	Trace	0	2b	
				3 wks. postop.	192/110						
				3 mos. postop.	220/130	1.023	35	Trace	0		
				6 mos. postop.	240/140	1.021	39	Trace	0		
				12 mos. postop.	244/140	1.020		0.1	0		
				21 mos. postop.	230-250 152	1.021	39	Trace	0		
30 W. Mc.	M	55	4 yrs.	Pre-op.	188-226 120-135	1.025		Trace		2b	
				5 wks. postop.	170-198 122-128	1.029	67	Trace			
				5 mos. postop.	195/120	1.027	75	Trace			
				12 mos. postop.	185-220 120-140	1.025		Trace			
31 G. P.	M	42	5 yrs.	Pre-op.	210-252 150	1.021	58	0.5	53	2b	
				3 wks. postop.	191/120						
				5 mos. postop.	210/144	1.021	62	0.1	4.0		
32 H. B.	F	43	8 yrs.	Pre-op.	200-245 130-145	1.025	47	0.1	3.0	2b	
				2 wks. postop.	220/120						
				3 mos. postop.	180/100	1.024	54	Trace	1.4		
				7 mos. postop.	240-260 150	1.023	60	Sl. tr.	0		
33 M. S.	F	42	5 yrs.	Pre-op.	210-222 130-134	1.027	92	Trace		2b	
				3 wks. postop.	190/112						
				10 mos. postop.	180-210 130-140	1.026	102	Trace			
34 R. H.	F	44	4 yrs.	Pre-op.	208-250 126-136	1.021	112	Trace		2b	
				3 wks. postop.	200/120						
				14 mos. postop.	240/144		77	Trace			

TABLE I—Continued

Case number and initials	Sex	Age at time of operation	Known duration of hypertension	Time of observation	Blood pressure	Concentrating ability of kidneys	Urea clearance	Urine		Classification in Table II	Remarks
								Proteinuria	Hematuria		
		years			mm. Hg	nonprotein specific gravity	per cent of mean normal	per cent	millions of r.b.c.'s per 12 hours		
35 A. V.	F	48	5 yrs.	Pre-op.	242-300	1.017	21	0.25		2b	
				1 mo. postop.	160-170 180-210	1.019	26	Trace			
				3 mos. postop.	120 230-240	1.016	24	Trace			
				6 mos. postop.	120-130 240-300	1.017	19	Trace			
					145-160						
36 I. B.	F	43	12 yrs.	Pre-op.	260/150	1.022	45	0.6		2b	
				1 mo. postop.	190/110						
				1½ mos. postop.	240/160	1.023	57	0.4			
37 F. R.	M	38	2 yrs.	Pre-op.	160-178	1.013	34	0.25	12	2b	Blood nonprotein nitrogen 56 mgm. per cent Blood nonprotein nitrogen 54 mgm. per cent
				2 mos. postop.	108 170/110	1.014	27	0.2			
				5 mos. postop.	170/110	1.015	27	0.22	16		
38 L. H.	M	46	3 yrs.	Pre-op.	195-215	1.028	96	Trace	1.1	2b	
				3 wks. postop.	116-130 140/90	1.027	80		0		
				6 mos. postop.	200/110		127	Trace			
39 W. B.	F	43	2 yrs.	Pre-op.	192-240	1.018	62			2b	Slight edema present
				3 wks. postop.	112-150 200/110						
				6 mos. postop.	236/140	1.022	71				
				9 mos. postop.	210-220 126-140	1.019	73				
40 C. V.	M	34	1 yr.	3 mos. pre-op.	230/150	1.019	47	0.33	0	2c	
				1 wk. postop.	240/156	1.018	47	0.33	1.5		
				3 wks. postop.	180/130						
				10 mos. postop.	220-250 150-170	1.011	16	0.3	0		
41 I. J.	F	55	5 yrs.	Pre-op.	268-300	1.019	38	Trace		2c	
				3 wks. postop.	130-170 220-270						
				10 mos. postop.	120 270 130-170	1.021	18	Trace			
42 E. H.	F	52	1 yr.	Pre-op.	230/130	1.024	69	Trace		2c	
				3 wks. postop.	160/110		49	Trace			
43 C. W.	M	45	6 mos.	Pre-op.	210/120	1.027	91	Sl. tr.	0	2c	
				3 wks. postop.	140/90						
				10 mos. postop.	185-190 125-130	1.022	45	Trace	1.8		

TABLE I—Continued

Case number and initials	Sex	Age at time of operation	Known duration of hypertension	Time of observation	Blood pressure	Concentrating ability of kidneys	Urea clearance	Urine		Classification in Table II	Remarks
								Proteinuria	Hematuria		
		years			mm. Hg	nonprotein specific gravity	per cent of mean normal	per cent	millions of r.b.c.'s per 12 hours		
44 F. S.	M	40	17 yrs.	Pre-op.	172-234	1.029	84	Trace	0	2c	
				3 wks. postop.	108-130 115-130		91	0	0		
				3 mos. postop.	80-90 194/124	1.025	82	0	0		
				7 mos. postop.	172/118	1.025	87	Trace	0		
45 H. Mc.	F	38	2 yrs.	Pre-op.	180/120	1.028	114	0.1	0	2c	
				1 wk. postop.	200/120						
				5 mos. postop.	205/130	1.021	89	Trace	0		
46 F. G.	M	35	3 mos.	Pre-op.	226-240	1.013	17	0.3	.9	2c	Nonprotein nitrogen 58 mgm. per cent  Died in uremia. Blood nonprotein nitrogen 114 mgm. per cent
				4 wks. postop.	150-160		13				
				6 wks. postop.	160/120 250						
				8 wks. postop.	144-150						
47 L. B.	F	21	3 mos.	Pre-op.	220/146	1.017	40	1.0	2.4	2c	Died in uremia
				2 wks. postop.	166/122						
				6 wks. postop.	220/140	1.018	46	0.6			
				8 mos. postop.							
48 I. B.	F	45	3 yrs.	Pre-op.	155-182 110	1.037	95	Sl. tr.	0	3	
				6 mos. postop.	210/130	1.034	103	Sl. tr.	0		

imately normal; in others it rose to various levels even to the preoperative value. Following this secondary rise the blood pressure in some cases remained unchanged, in others it again decreased, sometimes rapidly sometimes over a period of months.

The effect of splachnicectomy on the kidneys can best be considered in relation to the effect on the blood pressure. According to this relationship, the patients fall into different groups. Figures 1 to 8 illustrate the course of events in representative cases.

*Explanation of figures.* In each case the vertical line, topped by an arrow, represents the bilateral splachnicectomy. The time charted to the left of this line refers to the *known* duration of hypertension. The postoperative events are charted at irregular intervals, properly designated. The blood pressure charted 2 or 3 weeks following splachnicectomy represents the values at the time the patient was discharged from the hospital following operation. When the blood pressure fluctuated appreciably, the extremes are plotted and the intervening

space shaded. Although it is not a true representation, the values plotted for each occasion have been joined by a line in order to illustrate the trend of events.

In Figure 1 the changes in a patient (Case 1, W. L.) whose blood pressure after splachnicectomy remained below 160/100 mm. Hg, are shown. The urea clearance was normal in this patient before operation, whereas the concentrating ability was greatly reduced. The lack of parallelism of these functions of the kidneys in this disease has been pointed out previously (6). This is an unusually wide variation, however. At the time of discharge from the hospital the urea clearance was below normal. A temporary decrease in urea clearance in the early postoperative period has been observed in a few other cases. Following splachnicectomy, proteinuria promptly disappeared. Five months after operation the renal function had become entirely normal, and has remained so for more than two years.

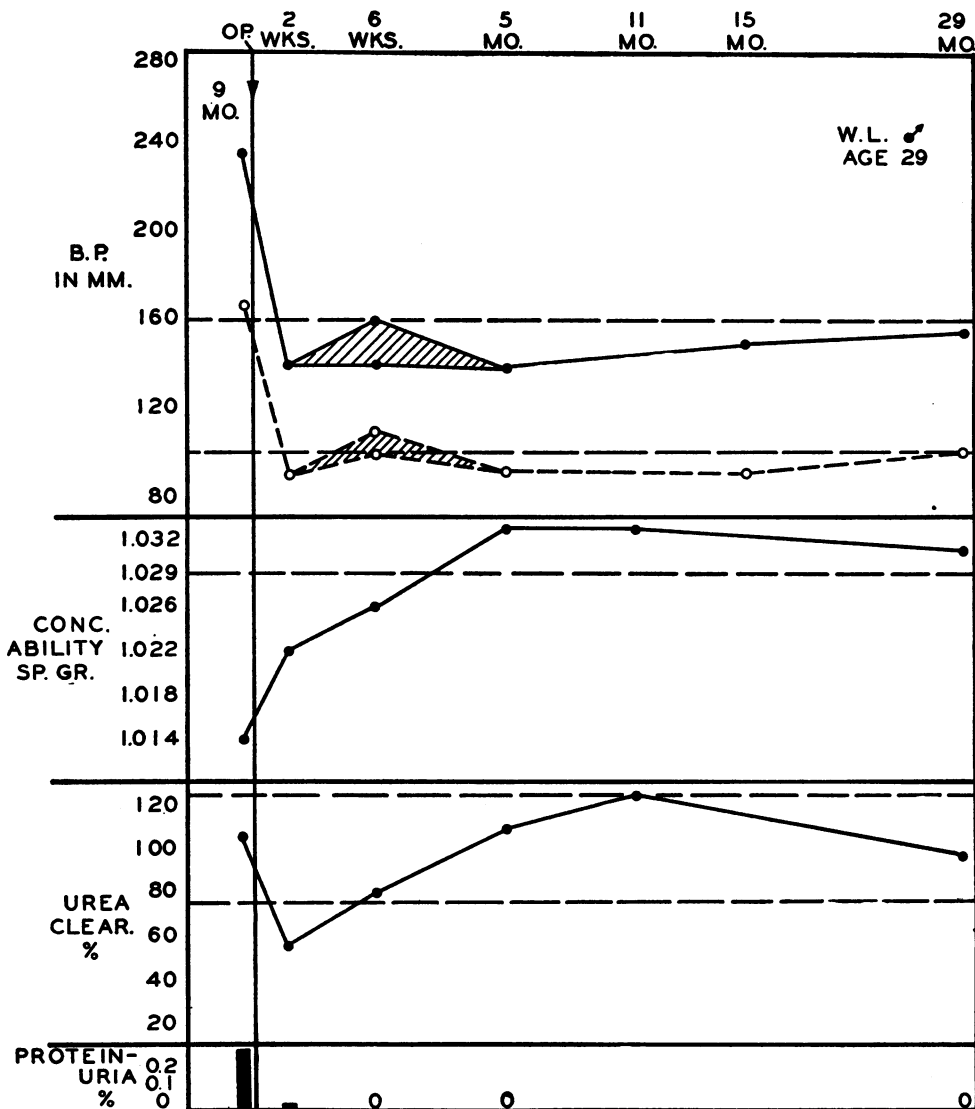


FIG. 1. BLOOD PRESSURE, RENAL FUNCTION AND URINARY FINDINGS IN CASE 1 (W. L.) WITH MARKED RELIEF OF HYPERTENSION.

Concentrating ability returned to normal following splachnicectomy.



TABLE II

The relation between renal function and blood pressure in 48 cases at the end of three months or longer after splanchnicectomy

	Number	Per cent
1. Blood pressure decreased:	24	50
A. To 160/100 or less. (3 cases followed 6 to 29 months).....	6	12.5
a. Renal function normal before and after operation.....	1	
b. Renal function impaired before operation, returned to normal after operation.....	3	
c. Renal function remained slightly impaired (4 months) after operation.....	2	
d. Renal function decreased after operation.....	0	
B. Not to 160/100, but more than 60 mm. systolic, or more than 30 mm. diastolic.....	8	16.6
a. Renal function normal before and after operation.....	2	
b. Renal function impaired before operation, improved after... ..	6	
c. Renal function decreased after operation.....	0	
C. From 30 to 60 mm. systolic, or from 15 to 30 mm. diastolic.....	10	20.9
a. Renal function normal before and after operation.....	1	
b. Renal function impaired before operation, improved after... ..	5	
c. Renal function impaired before operation, unchanged after... ..	3	
d. Renal function decreased after operation.....	1	
2. Blood pressure essentially unchanged:	23	48
a. Renal function normal before and after operation.....	2	
b. Renal function impaired before operation, unchanged after... ..	11	
c. Renal function impaired before operation, decreased after... .. (to death in uremia, 2)	8	
d. Renal function impaired before operation, increased after.....	2	
3. Blood pressure increased:	1	2
Renal function normal before and after operation (6 months)		

In Case 2, M. P. (Figure 2) there was a prompt return to normal of both the urea clearance and concentrating ability, and the disappearance of proteinuria, with relief of the hypertension.

In Case 4, V. E. (Figure 3) there was no impairment of renal function before operation, and the efficiency of the kidneys remained normal, or promptly returned to normal after a temporary decrease following splanchnicectomy, when the hypertension was relieved. This case illustrates that if urinary abnormalities exist, they may disappear or greatly decrease.

In many patients, blood pressure was markedly reduced, but not below 160/100 mm. Hg (Group 1, B of classification above). In such cases, if renal function had been normal, it remained so;

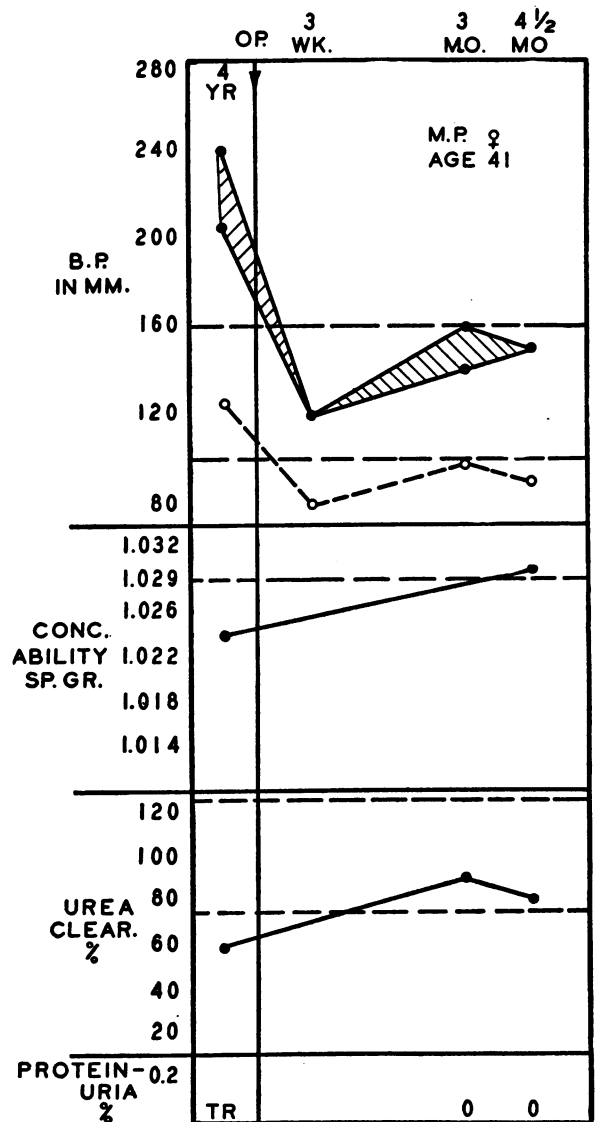


FIG. 2. DATA IN CASE 2 (M. P.), SHOWING A RETURN TO NORMAL OF THE CONCENTRATING ABILITY AND UREA CLEARANCE WITH RELIEF OF THE HYPERTENSION.

if it had been impaired, it improved and in some cases became entirely normal and the urinary abnormalities completely disappeared. Cases illustrating this effect are shown in Figures 4 and 5.

In some patients the blood pressure was decreased to a lesser degree (Group 1, C of classification above). In these persons, renal function usually improved if it had not been normal, or remained unchanged. In only one case (Case 24, L. B.) in this group was the concentrating ability found, fourteen months after operation, to be

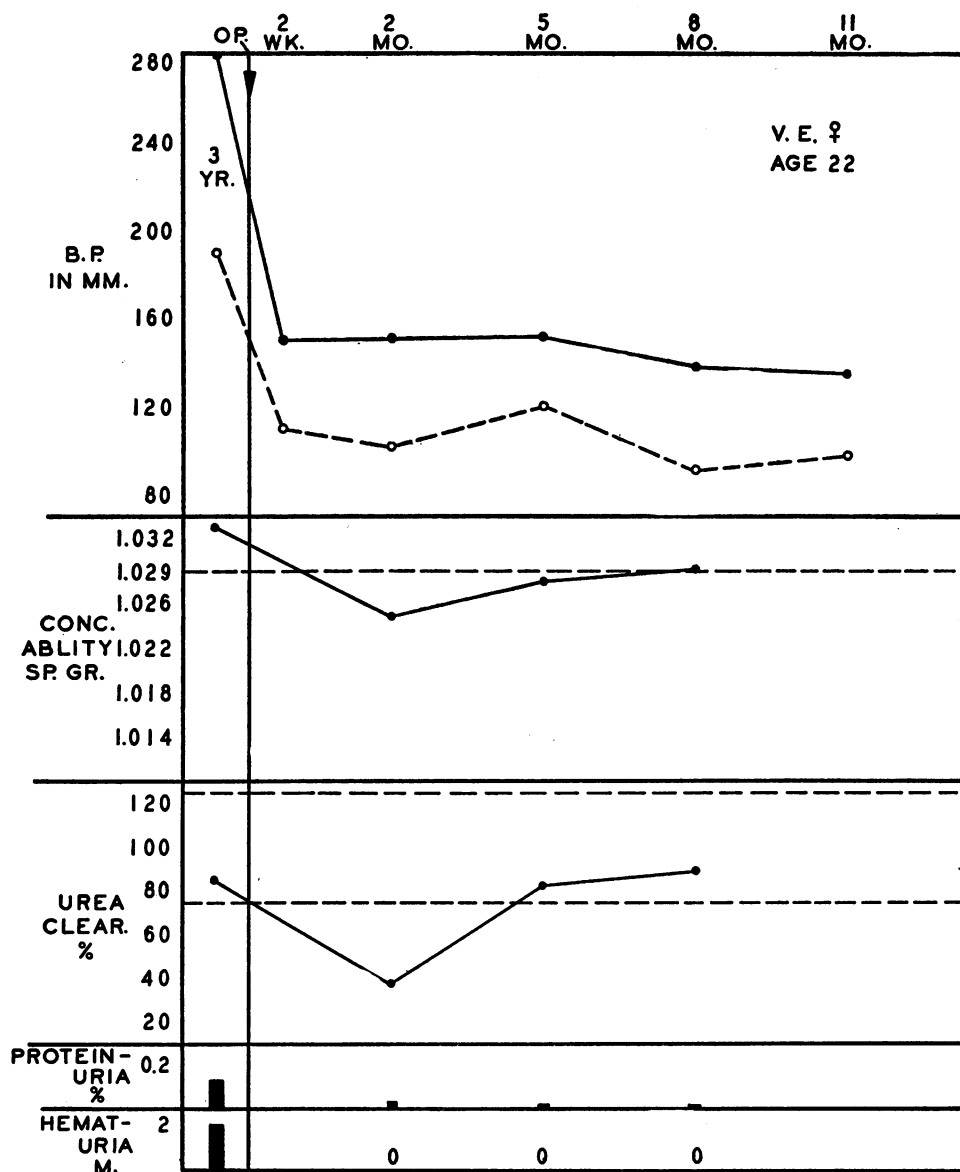


FIG. 3. DATA IN CASE 4 (V. E.), WHOSE RENAL FUNCTION WAS NORMAL BEFORE SPLANCHINECTOMY.

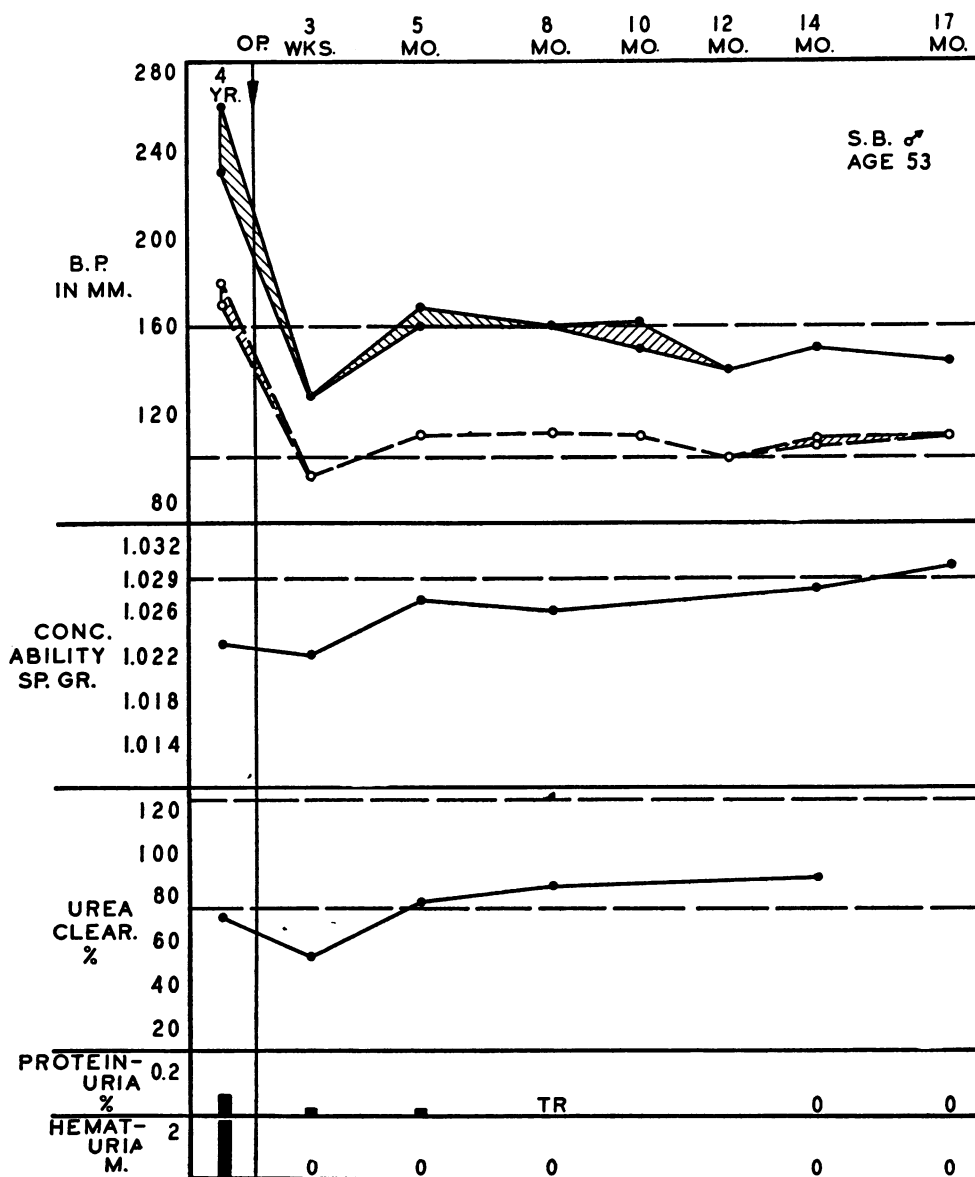


FIG. 4. CASE 8 (S. B.), SHOWING RETURN TO NORMAL RENAL FUNCTION AND NORMAL URINE WITH LOWERING OF BLOOD PRESSURE.

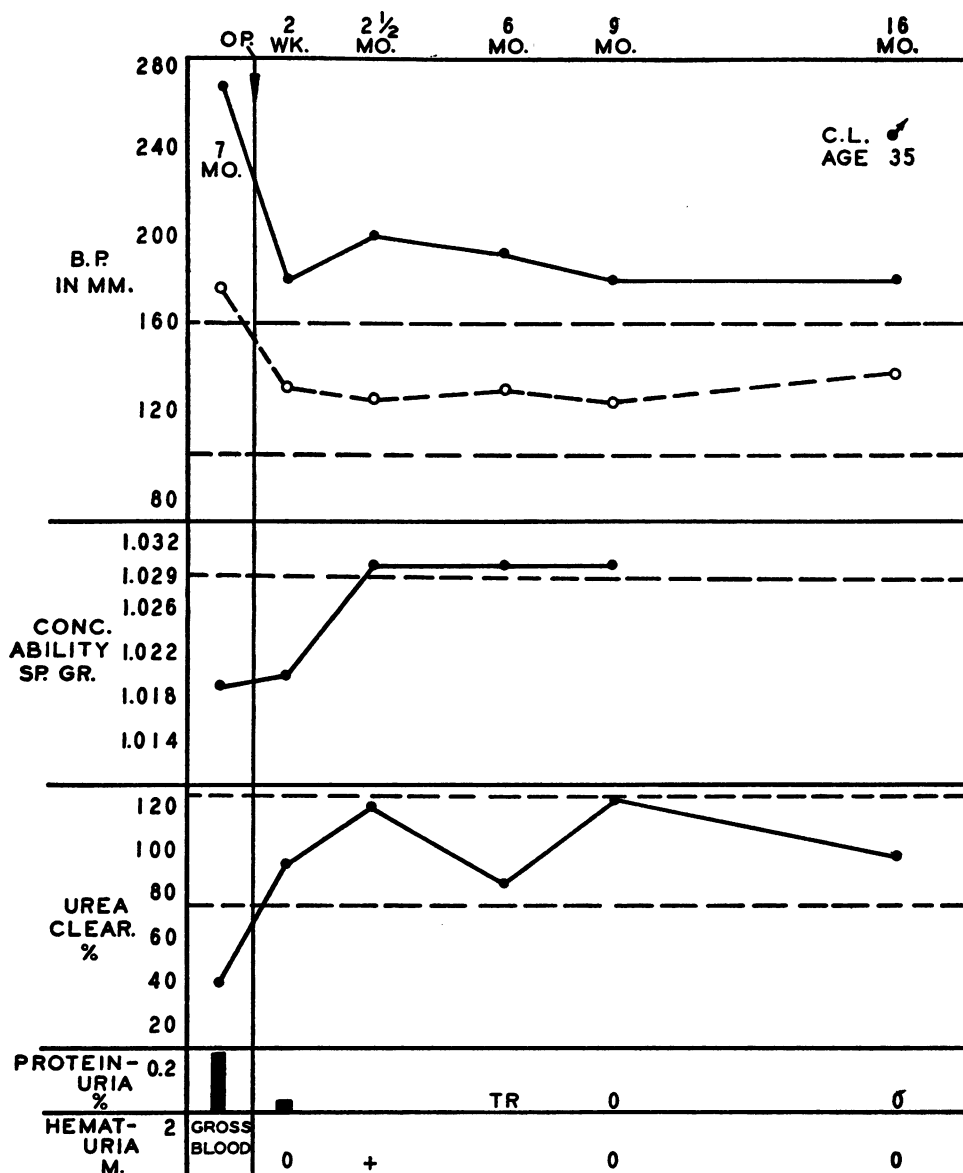


FIG. 5. SHOWING THAT RENAL ACTIVITY AND URINE PROMPTLY BECAME NORMAL IN CASE 7 (C. L.) WHOSE BLOOD PRESSURE WAS REDUCED BUT NOT TO THE LOW LEVELS ILLUSTRATED IN PREVIOUS CHARTS.

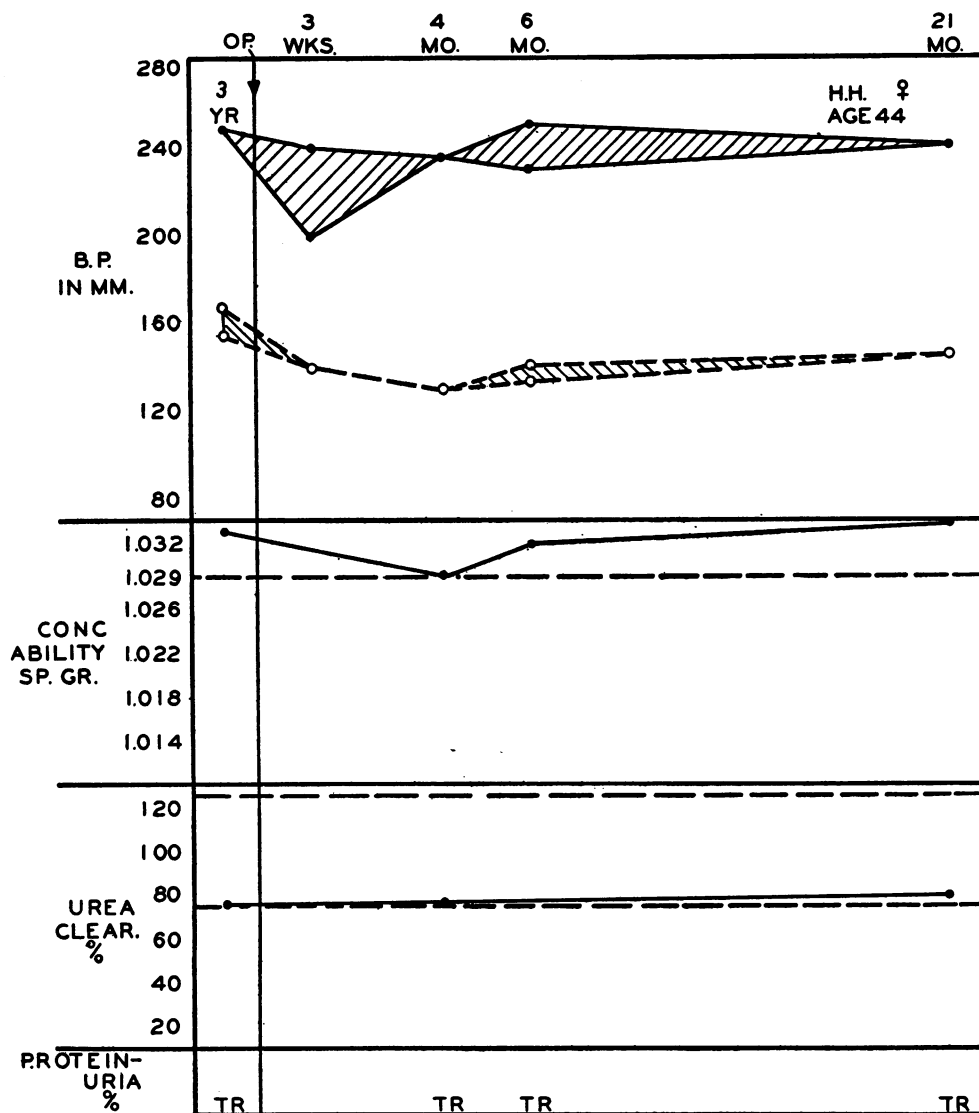


FIG. 6. SHOWING RENAL FUNCTION REMAINING NORMAL AFTER SPLANCHNICECTOMY IN CASE 25 (H. H.) WHO HAD NO LASTING DECREASE IN BLOOD PRESSURE.

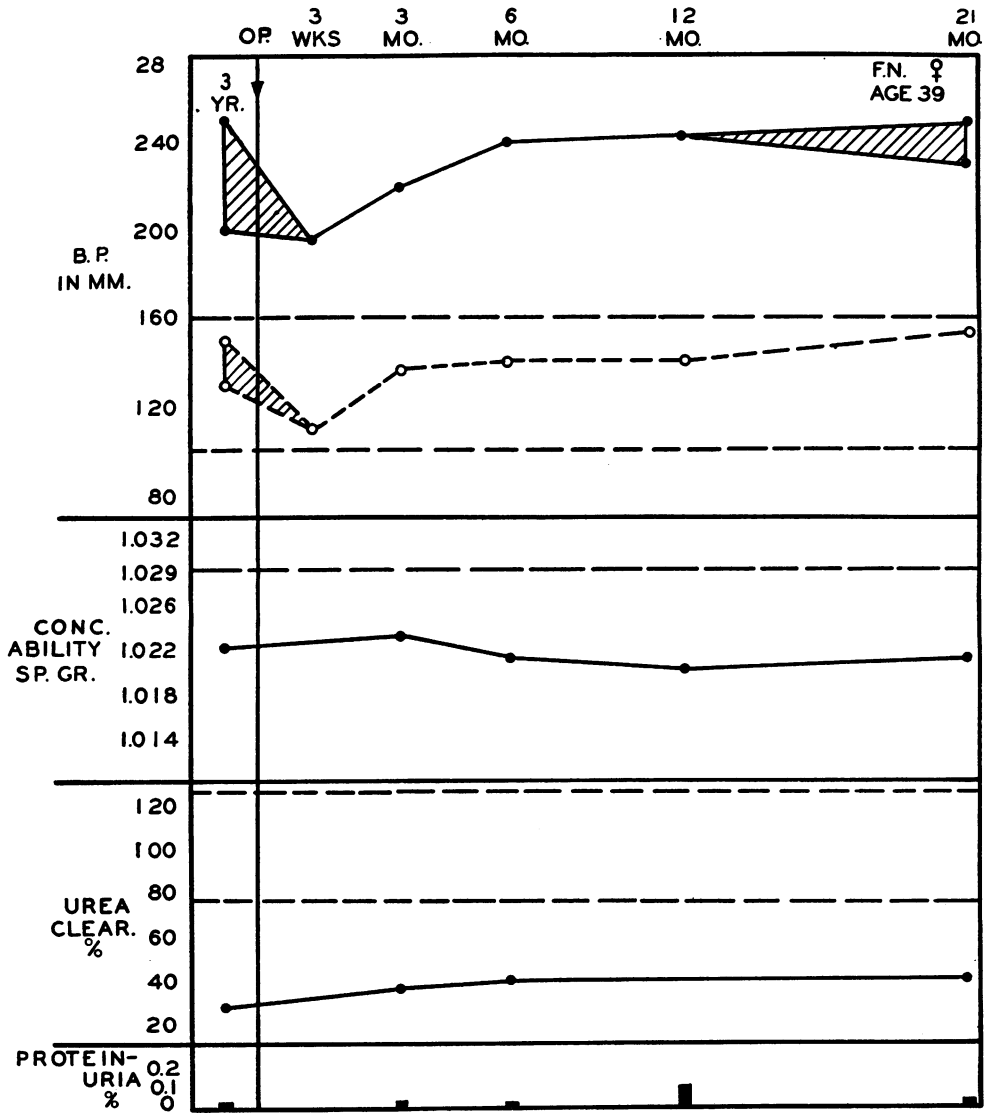


FIG. 7. REDUCED RENAL FUNCTION AND URINE REMAINED ESSENTIALLY UNCHANGED IN CASE 29 (F. N.) WHO HAD NO LASTING REDUCTION IN BLOOD PRESSURE.

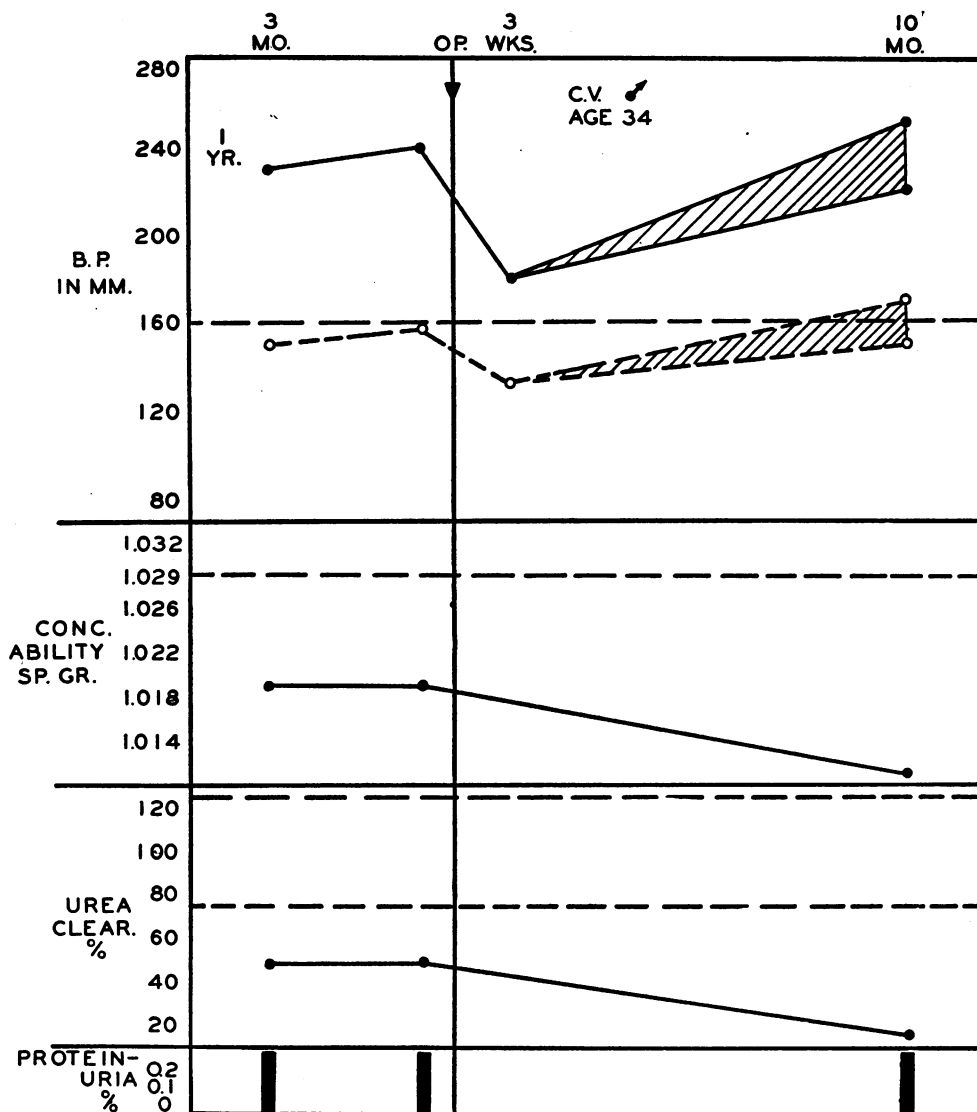


FIG. 8. SHOWING DECREASE IN RENAL FUNCTION AND PERSISTENCE OF PROTEINURIA IN CASE 40 (C. V.) WHOSE HYPERTENSION WAS NOT BENEFITTED BY SPLANCHNICECTOMY.

slightly decreased. (The blood pressure at this time averaged 185/120 mm. Hg.)

In 50 per cent of the patients comprising this study, the blood pressure did not remain reduced following splanchnicectomy. In general, the renal function in this group of cases either remained unchanged, or became gradually worse, in a manner just as would be expected if splanchnicectomy had not been performed (Figures 6, 7 and 8). In two such cases (Case 46, F. G., and Case 47, L. B.) renal function decreased progressively until death occurred in uremia. Two persons in this group (Case 27, H. S., and Case 28, T. A.) showed an improvement in renal function.

#### DISCUSSION

We wish to emphasize that this study is not meant to convey statistics regarding the effect of splanchnicectomy on blood pressure or other clinical results. Many more patients have been operated upon than we have been able to study in the manner here described. Symptomatic changes, ocular fundus and cardiac changes, mortality, etc., must of course be considered in a complete appraisal of results of this form of treatment. We have included data on blood pressure herein, and have grouped the patients according to changes in their blood pressure, only for convenience in discussion of the effect on the kidneys. Those persons whom we considered to have small decreases in blood pressure, and especially those whom we have been able to follow only three to six months, may be found after a longer period of postoperative study to have no lasting reduction in blood pressure. It should be noted, however, that in four patients (Cases 4, 7, 8 and 1) the blood pressure has remained at a remarkably low level in comparison with preoperative values, for 11, 16, 17 and 29 months, respectively, following splanchnicectomy.

From the data presented, it is evident that splanchnicectomy performed on patients with primary hypertension and normal kidney function, *does not harm* the kidneys, or interfere with their functional efficiency as measured by concentration and urea clearance test, whether or not significant decrease in blood pressure results. Page and Heuer (7) have likewise found that denervation

of the kidneys which resulted from sectioning the anterior nerve roots from the 6th thoracic to the 2d lumbar segment in a patient with essential hypertension, in no way interfered with the renal function even though the blood pressure was reduced to normal. Page (8) has also shown that reduction in blood pressure induced by medication, or resulting from direct renal denervation of one kidney did not alter renal function as measured by urea clearance. All of these observations, therefore, show that in cases of primary hypertension, renal efficiency is not dependent on high blood pressure, as has been so commonly thought. Thus the "compensatory theory" of the cause of the elevated blood pressure in patients with primary hypertension is disproven.

We have repeatedly observed that when hypertension is greatly relieved by splanchnicectomy, renal function that has previously been impaired, improves, and may even return to normal. This improvement in kidney function has shown itself *both* by an increase in concentrating ability, and by an increase in urea clearance, in a number of cases.<sup>1</sup> This indicates to us that the impairment of renal function is caused by vascular constriction, and that if constriction is relieved by splanchnicectomy, renal activity is benefitted.

In some cases we have observed, as have Page and Heuer (9), an improvement in proteinuria and hematuria, out of all proportion to changes in renal function.

That the results obtained by splanchnicectomy should differ so widely in different patients, from complete relief of hypertension, in some cases, to complete failure in others, is striking. We are at present unable to predict or account for these differences. Contrary to the findings of Page and Heuer (9), however, we find a definite association between changes in renal function and in blood pressure in most patients. Certainly, renal disease with marked impairment of function may accompany hypertensive vascular disease, and when present, disappears following relief of the hypertension by splanchnicectomy.

<sup>1</sup> Page and Heuer (9) found an increase in concentrating ability in 2 of 5 patients *with nephritis* whose kidneys were denervated, but found no alteration in urea clearance.



# SUMMARY

Data regarding the renal status and blood pressure in 48 patients with hypertensive vascular disease treated by bilateral splanchnicectomy are presented. This surgical procedure has greatly relieved hypertension in some cases, has benefitted others to a lesser degree, and has not influenced the blood pressure in still others. In general, the changes in the kidneys were associated with changes in blood pressure. In those patients who had a significant and maintained decrease in blood pressure, urinary abnormalities decreased or disappeared, and the renal function, if it had been impaired, improved—in several cases it became entirely normal. In a few cases with less decrease in blood pressure, renal function remained unchanged following splanchnicectomy. When hypertension was lowered in patients having normal renal function, the efficiency of the kidneys remained normal. When hypertension was not favorably influenced, renal function remained unchanged, or gradually became worse as would be expected in unoperated cases.

These observations show that in cases of primary hypertension, satisfactory renal function is not dependent on the high blood pressure; that hypertension is not compensatory to measurable renal damage; that marked impairment of renal function may accompany hypertensive vascular

disease, and that striking improvement of renal function follows relief of hypertension brought about by splanchnicectomy.

# BIBLIOGRAPHY

1. Peet, M. M., Splanchnic section for hypertension. A preliminary report. Univ. Hosp. Bull., Ann Arbor, 1935, **1**, 17.
2. Van Slyke, D. D., and Cope, C. L., Simplified colorimetric determination of blood urea clearance. Proc. Soc. Exper. Biol. and Med., 1932, **29**, 1169.
3. Lashmet, F. H., and Newburgh, L. H., An improved concentration test of renal function. J. A. M. A., 1932, **99**, 1396.
4. Lashmet, F. H., and Newburgh, L. H., An improved concentration test of renal function. II. Simple method for measuring proteinuria. J. A. M. A., 1933, **100**, 1328.
5. Addis, T., A clinical classification of Bright's diseases. J. A. M. A., 1925, **85**, 163.
6. Freyberg, R. H., The choice and interpretation of tests of renal efficiency. J. A. M. A., 1935, **105**, 1575.
7. Page, I. H., and Heuer, G. J., The effect of renal denervation on the level of arterial blood pressure and renal function in essential hypertension. J. Clin. Invest., 1935, **14**, 27.
8. Page, I. H., The effect on renal efficiency of lowering arterial blood pressure in cases of essential hypertension and nephritis. J. Clin. Invest., 1934, **13**, 909.
9. Page, I. H., and Heuer, G. J., The effect of renal denervation on patients suffering from nephritis. J. Clin. Invest., 1935, **14**, 443.