1 by the combination of bilirubin and pigment 2 from columns. This is contrary to the report of Nosslin(9) that, under similar circumstances, a "small but nevertheless distinct" band with a mobility of pigment 1 could be detected.

Summary and conclusions. Rat-fistula bile, isolated rat liver, liver slices incubated with bilirubin, and the hepatectomized dog were utilized to study the nature and sources of conjugated bile pigment. The technics of reverse-phase column chromatography, chemical-partition chromatography, and paper chromatography were employed and molar ratios were calculated. Probably pigment 1 is formed solely in extrahepatic sites. The evidence favors a bilirubin monoglucuronide structure for pigment 1 rather than a complex of bilirubin and pigment 2. In the dog, pigment 2 probably is formed only within the liver. It is suggested that bilirubin diglucuronide may be formed intrahepatically from bilirubin directly, as well as from part of the extrahepatic pigment 1.

Grateful Acknowledgment is made to Mr. Emory Van Hook for invaluable technical assistance.

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Received November 13, 1962. P.S.E.B.M., 1963, v112.

Renal Blood Flow in Acute Renal Failure Measured by Renal Arterial Infusion of Indocyanine Green. (28214)

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Measurements of renal blood flow in oliguric patients with acute renal failure are limited. Early reports using the para-aminohippurate (PAH) clearance and extraction technique(1,2), have been criticized on technical grounds for the very low extraction of PAH by the oliguric kidney. Clearances cannot be measured by this technique if anuria is present, and the extremely low figures for

* In receipt of a full time grant from Medical Research Council (Great Britain).
† In receipt of a grant from Royal Free Hospital.

renal blood flow (3% of normal) obtained with PAH were not confirmed when measurements were made with krypton (Kr^{85}) using the inert gas equilibration technique (3,4). However, this technique has also been criticized because of difficulties in obtaining an equilibrium of the gas content in arterial and renal venous blood(5) and the necessity to assume the solubility coefficient of krypton in renal tissue.

This report describes the measurement of renal blood flow in patients with acute renal failure using a constant infusion of indocyanine green (IG) into the renal artery(6). The measurements were made either before or after treatment by haemodialysis and the same catheters were used, therefore, for flow measurements and for haemodialysis.

Methods. The IG method requires catheterization of the renal artery and corresponding renal vein. A renal artery was catheterized under fluoroscopic control following percutaneous puncture of the femoral artery(7) and introduction of an Odman-Ledin plastic catheter(8). The corresponding renal vein was also catheterized by the same technique, passing a plastic catheter into one of the renal veins from the femoral vein. These catheters were used for haemodialysis using the percutaneous technique(9). Arterial blood was also sampled from the other femoral artery *via* a small polyethylene catheter. A loading dose of IG 0.3 mg per kg body weight was given intravenously and it was then infused at 0.5 mg per minute (in a volume of 1 ml) into the renal artery catheter by a Sigma constant infusion pump. After a 20 minute equilibration period, samples were obtained from the renal vein and femoral artery catheters (allowing for dead space sampling times). Indocyanine green was measured directly in plasma without extraction(10) and oxygen content of arterial and renal venous blood was measured spectrophotometrically(11). Renal blood flow for the catheterized kidney was calculated from the formula:—

$$RBF^R = \frac{I \times 1000}{V - A} \times \frac{100}{100 - PCV}$$

where RBF^R = right renal blood flow, ml per minute.

I = infusion rate of IG, mg per minute.

V = renal venous plasma concentration of IG, mg per l.

A = arterial plasma concentration of IG, mg per l.

PCV = packed cell volume.

The validity of this method and its comparison with PAH clearance and extraction values for renal blood flow have already been described(6). In 8 hypertensive subjects undergoing screening for renal artery stenosis there was no significant difference between the two methods. During the time taken to obtain a PAH clearance and extraction value for total renal blood flow it was possible to catheterize both kidneys consecutively and thus obtain a figure for renal blood flow for both kidneys by the indocyanine green method. In addition there was no significant difference between the blood flow of each kidney in these patients.

Measurements were obtained in 8 patients with acute renal failure in the anuric-oliguric stage (Table I). In 4 patients renal blood flow was also estimated during the recovery stage. The right kidney was used on all occasions and the results were expressed as flow per right kidney and doubled to give total renal blood flow. Renal oxygen consumption was calculated from total renal blood flow values.

Results (Table II). The mean renal blood flow in the anuric-oliguric stage averaged 440 ± 110 ml per min per 1.73m² for total renal blood flow (± = 1 standard deviation). Mean control values previously established

TABLE I. Clinical Data.

Case	Age (yrs)	Sex	Aetiology	Dialysis (No.)	Outcome
A.S.	48	♂	Carbon tetrachloride	1	Survived
A.K.	40	♂	Post surgical	4	Died
F.A.	52	♂	Obstructive jaundice	2	Survived
P.P.	50	♂	Pancreatitis	5	Died
H.P.	45	♂	Post surgical	1	Survived
R.R.	19	♂	Trauma	7	"
E.C.	21	♀	Gangrene of ovary	2	"
J.H.	19	♂	Gastroenteritis	2	"

TABLE II. Renal Circulatory Data in 8 Patients with Acute Renal Failure Examined at Various Stages of the Disease.

Case	Days after onset of oliguria	Urine volume (ml/24 hrs)	Blood urea (mg %)	C_{cr} (ml/min/1.73m²)	PCV (%)	Renal blood flow (ml/min/1.73m²) Total	% Normal	$(A\text{-}R)O_2$ (ml/100 ml)	ROC (ml/min/1.73m²)
A.S.	10	20	250	<1	32	600	53	1.8	10.8
	50	1500	30	75	40	900	80	1.9	17.0
A.K.	5	0	200	<1	26	560	50	1.7	9.5
F.A.	6	150	290	<1	30	420	37	1.3	5.5
	45	2100	45	65	39	740	66	1.5	11.1
P.P.	5	300	270	<1	31	500	45	1.3	6.5
H.P.	7	50	150	<1	31	320	29	1.5	4.8
R.R.	4	100	250	<1	28	340	30	1.4	4.8
	60	1300	19	100	35	720	64	—	—
E.C.	7	70	200	<1	27	460	41	1.1	5.0
	30	2000	22	70	30	800	72	1.3	10.5
J.H.	4	0	250	<1	36	320	29	1.0	3.2
	Control values (8 hypertensive patients being screened for renal artery stenosis).				mean	1110		1.49	16.8
					S.D.	260		.13	2.26

PCV = packed cell vol.
C_{cr} = 24 hr total endogenous creatinine clearance.
$(A\text{-}R)O_2$ = arterio-renal venous oxygen content difference.
ROC = renal oxygen consumption.

(6) were 560 ± 130 ml per min per 1.73m² (right kidney) and 1110 ml per min per 1.73m² for both kidneys. The reduction in blood flow to the anuric kidney averaged 61% (Fig. 1). Mean renal oxygen consumption was reduced to 6.39 ± 2.4 ml per min per 1.73m² (mean control value 16.8 ± 2.26 ml per min per 1.73m²) but arterio-renal venous oxygen content difference averaged 1.39 ± 0.27 ml per 100 ml whole blood which was not significantly different from the mean control figure of 1.49 ± 0.13 ml per 100 ml whole blood. During the recovery phase, renal blood flow and renal oxygen consumption increased to 70% of normal while the arterio-renal venous oxygen content difference was not significantly altered.

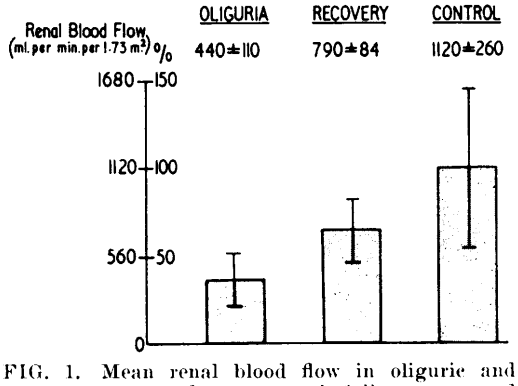

FIG. 1. Mean renal blood flow in oliguric and recovery stages of acute renal failure compared with control values obtained in hypertensive subjects during screening for renal artery stenosis. Total renal blood flow (obtained by doubling blood flow measured through right kidney) is expressed as a percentage of control value and as an absolute figure. Ranges about the mean equal 2 standard deviations; ± equals 1 standard deviation.

Discussion. The observation that renal blood flow and oxygen consumption in acute renal failure are about 40% of normal confirms the earlier results using Kr^{85}(4), and suggests that the criticism of the original PAH values of 3%(1,2) is justified. The persistence of extremely low creatinine clearances (<1 ml per minute), oliguria and renal failure cannot be explained by reduction in total renal blood flow alone, as values of 40% are often seen in chronic renal disease without oliguria, gross nitrogen retention or such low creatinine clearances. The reduction in oxygen consumption by the anuric kidney is consistent with the reduction in blood flow as it is known that renal extraction of oxygen does not increase when renal blood flow is reduced(12).

It has recently been suggested that the majority of oxygen consumed by the kidney is utilized for reabsorption of filtered sodium (13,14). This would therefore suggest that in the anuric kidney the filtered load of sodium is reduced by the same order as the oxygen consumption, suggesting a similar reduction in glomerular filtration rate. If the glomerular filtration rate of the anuric kid-

ney is 40% of normal then the total filtrate must be reabsorbed to produce anuria. Alternative explanations, however, would be that the metabolic work for sodium reabsorption is greater in the anuric kidney or that oxygen is being utilized for other purposes. Thus the glomerular filtration rate might be reduced far more than renal blood flow in the anuric kidney.

The increase in renal flow seen during the recovery phase of the illness suggests that renal ischaemia may play some part in maintaining the oliguric stage of acute renal failure.

Summary. The renal blood flow was measured by a constant infusion of indocyanine green into a renal artery in 8 patients with acute oliguric renal failure. There was an average reduction of renal blood flow to 40% of normal. Renal oxygen consumption was similarly reduced. However, renal arteriovenous oxygen content difference was not significantly altered from control values. In the recovery phase renal blood flow and oxygen consumption increased to 70% of normal. The persistence of renal failure in the acute oliguric phase could not therefore be explained by total reduction in renal blood flow as had previously been postulated.

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Received November 16, 1962. P.S.E.B.M., 1963, v112.

Parabiotic Intoxication in F_1 Hybrid Mice After Immunological Depression of the Parent Strain.* (28215)

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Parabiotic union performed between F_1 hybrid mice and members of one of the parental strains frequently results in wasting of the F_1 partner ending in its death. This syndrome has been called parabiosis intoxication. While the affected F_1 partner develops a hunched and sickly appearance, loses weight and becomes severely anemic, the non-intoxicated parental strain partner becomes polycythemic. The similarity between the intoxicated parabiont and the animal suffering from homologous disease has been pointed out(1-4), and it has been suggested that some or perhaps all of the phenomena observed in parabiosis intoxication may depend upon an immunological reaction by the parental strain partner against the hybrid member of the parabiotic pair. Tokuda and MacGillivray(5) have recently suggested that immunologically competent cells of the parental strain partner might react against the tissue antigens of the hybrid, leading to constriction and occlusion of the capillaries carrying blood from the parental

* Aided by grants from U.S.P.H.S., Am. Cancer Soc., Minnesota Heart Assn., Am. Heart Assn., and the National Foundation.