Table 1

SOME PARAMETERS OF SURFACE NEPHRONS IN Squalus acanthias

No.	BW kg	KW g	Diameter μ	Linear flow velocity μ/sec	Flow rate 10^{-6} ml/min
1	3.0	8.6	50	187	22
2			50	281	33
3			50	281	33
4			50	225	27
5	2.1	6.0	50	173	20
6			50	207	24
7	4.5	12.8	50	190	23
8	0.9	3.6	40	112	9
9			33	252	13
10			40	207	16
11	1.7	5.9	50	90	11
12		5.9	50	108	13
μ = 12			47 ± 6	193 ± 63	20 + 9

culated from linear velocity and radius. It should be noted that the former represents a minimum value for single nephron GFR since in the normal state all glomeruli are probably not active. The reappearance of dye in a second population of surface loops 100-300 seconds after injection identifies these more numerous structures as distal convolutions (Ghouse and Brennan, Section 5).

In a few experiments epinephrine (1 mg kg^{-1} BW) was given after the initial observations had been recorded. After epinephrine it was noted that portions of kidney surface which previously had appeared avascular now became filled with blood. Linear velocity of proximal tubular fluid, however, did not appear to be increased. From these preliminary studies it would appear likely that the well-known effect of adrenalin increasing GFR in this animal probably operates by augmentation of renal blood flow and recruitment of resting glomeruli.

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1968 #11

EFFECT OF EPINEPHRINE AND ACETYLCHOLINE ON INTESTINAL VASCULAR RESISTANCE OF Squalus acanthias

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Studies of intestinal vascular resistance in mammals have indicated that intravenous or intra-arterial injection of epinephrine results in either an increase or no change in resistance to blood flow (Texter, E. C. et al., J. Lab. Clin. Med. 64:624-30, 1964) while acetylcholine decreases intestinal vascular resistance (Boatman, D. L. and Brody, M. J., J. Pharm. and Exptl.

Therap. 142:185-91, 1963). The present studies are a preliminary report on the effects of these agents on resistance to blood flow through the intestine of Squalus acanthias.

Dogfish, 2-7 Kg were injected with sodium pentobarbital (20 mg/Kg) and oxygenation of blood accomplished by perfusion of sea water (12° -15° C) through the spiracles of the intact fish. The lower intestine was exposed by a midline abdominal incision and the anterior mesenteric artery ligated. The hepatic portal vein was cannulated with the largest size polyethylene tubing which would conveniently fit into the vessel and connected to an outflow J-tube from which flow was measured using a graduated cylinder and a stopwatch. Since the volume blood flow through the intestine was small, flow measurements were made over periods which ranged from 3-7 minutes. Transient changes in resistance to blood flow were, therefore, not possible. Measurements were made of systemic arterial pressure (dorsal aorta), intestinal arterial perfusion pressure (coeliac artery) and intestinal venous pressure (hepatic portal vein) by inserting small gauge needles (#26) into the lumen of the coeliac artery and portal vein and a large gauge needle (#20) into the dorsal aorta. All pressures were measured with Statham strain gauges and continuously recorded on a direct writing oscillograph. Epinephrine and acetylcholine were administered by bolus injection (1-2 ml) into the dorsal aorta through the dorsal aortic pressure cannula. Injections of 1-4 ml of elasmobranch ringers produced no significant hemodynamic alterations.

Intraarterial injection of epinephrine (2-8 μg/Kg) resulted in a rise in both dorsal aortic and coeliac artery pressure which persisted for periods of 30-90 minutes. Concomitantly, hepatic portal vein pressure and flow remained unchanged. Intraarterial injection of acetylcholine (2-12 μg/Kg) resulted in a rapid decrease in dorsal aortic pressure which slowly increased toward control pressure levels over a period of 1-4 minutes. There was an associated transient decrease in coeliac artery pressure followed by a return to control value when low doses of acetylcholine were used (2 μg/Kg or less) and an increase above control values when doses above 2 μg/Kg were used. The increase in pressure above control values was sustained for several minutes after which there was a return to the control pressure level. Portal venous pressure either decreased or remained unchanged in association with either a decrease or no change in venous outflow, respectively. The data are summarized in Table 1.

Particularly in the intestine, the effect of intraarterial infusions of vasoactive substances on vascular resistance to blood flow is dependent not only on the direct action which these agents have on vascular smooth muscle, but also on the change in compliance or tonus of the smooth

Table 1

Experimental procedure	No. of observations	Pressure (mm Hg)			Flow (ml/min)	Resistance (ml/min/mm Hg)
		Dorsal aorta	Coeliac artery	Hepatic portal vein		
Control	49	29.5	16.4	5.5	2.18	5.00
Epinephrine	17	50.2	25.7	4.8	1.92	10.89
Acetylcholine (high dose)	16	28.4	18.9	5.2	1.39	9.85
Acetycholine (low dose)	6	27.6	14.2	4.6	1.97	4.87

muscle of the gut wall. Thus, an agent which dilates vascular smooth muscle may decrease intestinal wall compliance (increase tonus) and the transmural pressure across the blood vessel wall will remain unchanged, resulting in no change in blood flow or pressure and hence resistance. Since measurements of intestinal compliance were not made in this study, it is difficult to interpret the factors responsible for increased vascular resistance during epinephrine infusion. The studies of Hiatt et al. (Bull. MDIBL 6:22-34, 1966) and Moore and Hiatt (Bull. MDIBL 7:32-33, 1967) indicate that epinephrine has a stimulatory effect on gastrointestinal smooth muscle—but their data do not include the lower intestine. The possibility remains then, that increased resistance to blood flow through the dogfish intestine may result from either arteriolar constriction, increased wall tension, or both.

Acetylcholine, in doses below 2 μg/Kg appeared to produce a net decrease in resistance to blood flow. The results, however, were variable and the pooled data show no significant change. At higher doses, acetylcholine increased the resistance to blood flow. Acetylcholine has been found to have no effect on intestinal smooth muscle of the lower intestine (Moore, personal communication). If this is the case then one interpretation of these data is that higher concentrations of acetylcholine produce vascular vasoconstriction in this preparation. The fact that coeliac artery pressure increased even when systemic arterial pressure was decreased, would tentatively support this conclusion.

The data in these studies are not adequate to permit clear conclusions about those factors which increase or decrease vascular resistance to flow. Decreased intestinal wall tension increases vessel transmural pressure which would tend to increase vessel caliber and lower vascular resistance. The converse is also true. Such activity may mask the effect of substances that increase or decrease vessel caliber by acting on vascular smooth muscle. Further studies are needed to clarify the effects of acetylcholine and epinephrine on these interrelated factors in the lower intestine of Squalus acanthias.

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1968 #12

FINE STRUCTURE OF TRANSPORT EPITHELIA IN FUNDULUS AND SQUALUS

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Recent physiological studies on the transport of salt and water have led to theories which stress the role of intercellular space in epithelial structures. The "middle compartment" of the Curran model and the "standing osmotic gradient" theory of Diamond and Tormey have been proposed in explanation of results obtained in studies on intestine, gall bladder, kidney and salt glands. Morphological evidence supporting these hypotheses has been obtained in some studies under measured transport conditions. Although osmotic gradients across the epithelia have been controlled, little attention has been paid to the effects of hydrostatic pressure on the configuration and volume of this compartment.

The isolated intestine of Fundulus heteroclitus adapted to fresh water and to sea water has been prepared to electron microscopic examination in relation to the osmotic and hydrostatic pressures imposed across the epithelium. Isolated perfused preparations of the spiral valve of