5 hours after the initiation of the perfusion (78.5 ± 15.9% of the administered dose). Additionally, a significant increase in bile flow (7.12 ± 2.16 μl hr^{-1} g^{-1} liver) was observed in 7 studies during the 3 hours following NaTc administration as compared to controls (4.17 ± 2.32, $p < 0.0125$).

These observations indicate that the isolated perfused skate liver is a useful model for the study of bile secretion in elasmobranchs when maintained at the normal temperature of sea water.

EFFECT OF ANGIOTENSINS AND EPINEPHRINE ON VASCULAR RESISTANCE OF ISOLATED DOGFISH GUT

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Pressure/flow curves were obtained from 11 isolated dogfish gut preparations taken from fish averaging 5 kg in weight. The previously described preparations (Opdyke and Wilde, Am. J. Physiol., 229:1141-1146, 1975) were perfused via the coeliac artery with oxygenated dogfish blood-elasmobranch saline mixture adjusted to 12% hematocrit (Hct) (low end of normal Hct range in dogfish). The weight of the preparations averaged 278 gm (range, 142-358 gm). A calibrated positive displacement pump (Harvard 1405) was used to provide known inflow rates. Inflow and outflow pressures were monitored by carefully calibrated Statham P23AA strain gages and a CRO recorder system (Electronics for Medicine IR4). Outflow pressure was held constant by fixing the orifice of the portal vein outflow cannula at the level of the portal vein which was approximately 2 cm above zero pressure reference level. The pressure gradient, coeliac artery to portal vein, was measured in each preparation at 3 to 9 different rates of inflow. A pressure/flow curve was constructed from these data for each preparation.

Following the collection of the data necessary to characterize the pressure/flow relationship, each of seven preparations was perfused in turn with oxygenated blood-saline mixture containing 1 μg/ml of angiotensin I, angiotensin II or epinephrine. The perfusate containing each compound was recirculated for several minutes following which the preparations were perfused with fresh blood-saline mixture containing no additives for 10 minutes or more before commencing the next trial. Inflow and outflow pressures were monitored continuously throughout each trial and recovery period. Inflow rate was the same for all trials in each preparation. Thus, any change in pressure gradient indicated a change in the resistance to blood flow according to the relationship

$$R = (P_i - P_o/F) \times 1332$$

where R = resistance to blood flow in dyne sec/cm^5; P_i = inflow pressure; P_o = outflow pressure (both in mm Hg); F = blood flow rate in ml/sec and 1332 = the factor for converting to cm/gm/sec units.

Figure 1 shows the pressure/flow relationship in three representative experiments. The relationship appears to be a linear one over the range of inflows studied as indicated by the fit of the calculated linear regression lines and the correlation coefficients of each experiment (Table 1). Critical closing pressure (inflow pressure at cessation of flow) was between 2 and 6 mm Hg in 8 of the experiments which is reasonable for low pressure systems. By using the means of all our observations of pressure gradient (22.95 mm Hg) and inflow (0.496 ml/sec) the

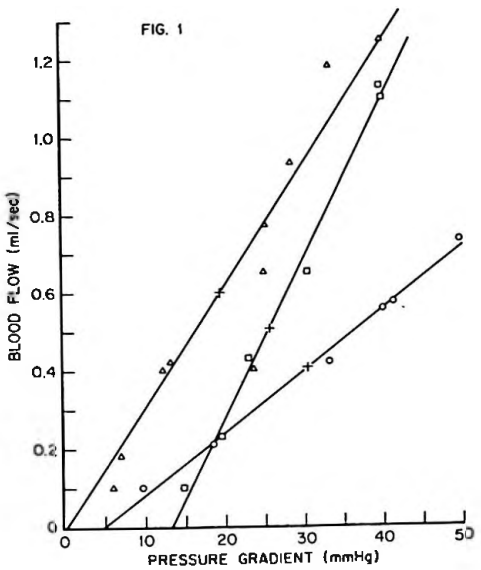

Figure 1. Blood pressure/blood flow regression in isolated dogfish gut. The cross indicates the origin for deviations; $\bar{X}$ = mean pressure, $\bar{Y}$ = mean flow. Additional data concerning these three representative experiments are found in Table 1. The plot identified in this figure by the Δ corresponds to experiment 10 in Table 1; □ , to experiment 6; and o, to experiment 5.

gut blood flow resistance can be calculated to be 60,052 dyne sec/cm^5 for a gut preparation averaging 2.78 gm in weight. The calculated resistance for all 70 observations of pressure/flow ranged from 22,664 to 195,994 dyne sec/cm^5. The lower resistances were associated with higher flow rates and correspondingly higher pressure gradients (regression equation, $Y = 106{,}934 - 70{,}401\ X$; $r = 0.3379$).

The resistance to blood flow appears to be high considering the fact that the vascular compliance ($\Delta P/\Delta V$) of the isolated dogfish gut preparation is large (Opdyke and Wilde, 1975, ibid.). Even so, this calculation of flow resistance appears to be low if one compares it with gut resistance calculated according to parameters published by Peirce et al. (Bulletin, MDIBL, 7:40-45, 1967) for cardiac output (1.4 liters/hour/kg) and Kent, Peirce and Peirce (Bulletin, MDIBL, 13:64-66, 1973) for the fraction of the cardiac output (6.7%) perfusing the G.I. tract exclusive of the liver. The resistance to blood flow would be 508,380 dyne sec/cm^5 if a pressure gradient of 23 mm Hg was assumed (the averaged pressure gradient in our series of 70 observations). However, if one assumes a near-minimal pressure gradient of 12 mm Hg the gut resistance could be calculated to be as low as 266,400 dyne sec/cm^5, which is still an awesomely high resistance to blood flow in the gut.

No measurable increases in resistance to blood flow were observed in any of the isolated gut experiments during perfusion with angiotensin I or angiotensin II. Intravascular injection of either of these polypeptides (Beckman Angiotensin I; Beckman Angiotensin II or Ciba Angiotensin II) into an intact fish results in a marked pressor response. On the other hand, epinephrine did cause a highly significant increase in resistance to blood flow in each experiment (+ 42 ± 8%) which

TABLE I

PRESSURE/FLOW STUDY. MEANS OF PRESSURE AND FLOW, REGRESSION EQUATION AND CORRELATION COEFFICIENT FOR EACH OF ELEVEN EXPERIMENTS.

Expt. No.	No. of P/F Observations	ΔP, mmHg $\bar{X}$ and range of Pressures	Flow ml/sec $\bar{Y}$ and range of flows	Regression Equation $Y = a + b X$	Correlation Coefficient r
1	7	11.37 (3.7 - 19.0)	0.430 (0.21 - 0.80)	Y = 0.0931 + 0.0296X	0.6800
2	8	17.36 (5.5 - 26.1)	0.524 (0.09 - 0.9)	Y = -0.1477 + 0.0387X	0.8042
3	5	24.36 (10.1 - 34.8)	0.528 (0.11 - 0.95)	Y = -0.1202 + 0.0274X	0.8020
4	8	25.05 (11.4 - 47.7)	0.430 (0.09 - 0.7)	Y = 0.1445 + 0.0114X	0.5408
5*	5	30.52 (9.8 - 49.9)	0.406 (0.06 - 0.47)	Y = -0.0704 + 0.0156X	0.9939
6*	5	25.57 (14.7 - 39.8)	0.506 (0.10 - 1.13)	Y = -0.5435 + 0.0410X	0.9871
7	5	24.88 (12.9 - 39.7)	0.488 (0.18 - 0.95)	Y = -0.0982 + 0.0236X	0.7557
8	7	28.88 (17.4 - 39.7)	0.471 (0.15 - 0.77)	Y = -0.3196 + 0.0278X	0.7489
9	8	23.48 (11.9 - 39.9)	0.625 (0.16 - 1.32)	Y = -0.4117 + 0.0441X	0.8422
10*	9	19.43 (6.0 - 33.3)	0.559 (0.10 - 1.18)	Y = -0.0857 + 0.0332X	0.8507
11	3	24.44 (13.2 - 34.1)	0.403 (0.20 - 0.63)	Y = -0.0876 + 0.0200X	0.9502

* Plotted on Fig. 1

demonstrated that the vasculature of the preparations was capable of vasoconstricting. The results with epinephrine also provide evidence that the isolated gut preparations were not maximally vasoconstricted initially which may have been a logical inference if drawn only from the pressure/flow studies described above.

The results with angiotensins and epinephrine are interpreted as evidence to support a hypothesis previously suggested (Opdyke and Holcombe, Fed. Proc., 35:705, 1976) that angiotensin II produces its pressor response in dogfish solely by releasing catecholamines (epinephrine) from chromaffin tissue, none of which has been found in the gut of the dogfish. Thus, the mechanism for the pressor response in dogfish may be completely different from the mechanism of response in mammals.

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