the dog). Indications are that the dogfish spleen does not sequester erythrocytes. Hence, the decrease in hematocrit may be due to a very rapid increase in plasma volume.

Phentolamine apparently is not as an effective alpha blocker in the dogfish as in mammals. Propanolol, on the other hand, effectively blocks the vasodepressor effect of isoproterenol. These observations suggest that qualitative differences in the organization of autonomic control of the circulation may exist between this species and mammals.

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1969 #27

HEMODYNAMIC RESPONSES OF Squalus acanthias TO IMPOSED STRESS

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Six fish Squalus acanthias, 2-6 Kgm, were lightly anesthetized with pentobarbital sodium (20 mgm/Kgm). Short cannulae or catheters connected to P23AA Statham gages were placed in the ventral and dorsal aortae while the gills were perfused with seawater. Arterial pressures were recorded (Electronics-for-Medicine IR-4) by a relatively high fidelity recorder system (resonant frequency of catheter-transducer greater than 25 cps). Responses to injections of L-epinephrine, saline, $CaCl_2$ and isoproterenol in random order were observed. The object of the experiments was to produce a variety of cardiovascular loadings which would elicit cardiovascular reflexes or reveal physical characteristics of the arterial system of this species. The responses have been interpreted in relation to typical responses in mammalian species.

Injections (dorsal aorta) of L-epinephrine (2×10^{-5} mgm/Kgm); saline, (30 ml in 5 ml) increments/30 seconds); and $CaCl_2$ (1 ml, 2M), increased the foot to peak time of both ventral and dorsal aorta pressure pulses. The delay in transmission time of the pressure pulse between ventral and dorsal aorta (mean distance approximately 40 cm) was decreased by all three interventions. Systolic, diastolic and pulse pressure increased consistently in response to L-epinephrine injection and saline loading. However, in response to L-epinephrine average dorsal aortic systolic, diastolic and pulse pressure increased more than ventral aortic pressure (ventral/dorsal aortic systolic pressure increases were 12.0 and 15.7 mmHg respectively; diastolic, 9.4 and 11.3 mmHg; pulse pressure, 2.8 and 4.2 mmHg). But in response to saline loading ventral aortic pressures increased more than dorsal aortic pressures (ventral/dorsal systolic pressure increases were 10.8 and 7.0 mmHg, respectively; diastolic, 2.5/2.2 mmHg, pulse pressure, 8.5/5.1 mmHg). Consideration of these results and application of mammalian hemodynamic concepts result in tentative conclusions that: the ventral aortic system is less compliant than the dorsal aortic system (response to saline loading); that the dorsal aortic system perhaps vasoconstricts to a greater degree than the ventral aortic system in response to L-epinephrine (greater elevation of pressure); but that the predominant effect of both L-epinephrine and saline loading was to increase cardiac stroke volume (increase in pulse pressure). The latter point leads to consideration of the effect of L-epinephrine and saline loading on cardiac cycle length; saline loading consistently (all 6 trials) increased cycle length; L-epinephrine injection resulted in four instances of increased cardiac cycle length and two decreases. Obviously, the increase in pulse pressure

response can be related to the increase in cardiac cycle length and no valid conclusion about vasoconstrictor activity in response to L-epinephrine can be drawn. The decrease in pressure pulse transmission time would be evidence for significant vasoconstrictor activity (increased arterial tone) only if arterial pressure had remained constant since increased arterial pressure per se will decrease transmission time.

The responses to calcium chloride injection resembled those obtained with L-epinephrine and saline loading. However, the responses were less consistent, particularly in respect to effect on cardiac cycle time (3 increases, 2 decreases), with a corresponding inconsistency in pulse pressure change. $CaCl_2$ effects are probably predominently cardiac.

Isoproterenol (2×10^{-5} mgm/Kgm) consistently decreased both ventral and dorsal aortic systolic, diastolic and pulse pressure. Ventral aortic systolic pressure decreased more than dorsal aortic pressure (-12.4 vs -10.4 mmHg) but dorsal aortic diastolic pressure decreased more than ventral aortic pressure (-4.2 vs -5.5 mmHg). This again suggests that the ventral aortic system is less compliant than the dorsal aortic system, or that the dorsal aortic system possesses more vasoconstrictor tone. However, the most important factor in the reduction of arterial pressure was undoubtedly a decrease in cardiac stroke volume since pulse pressure decreased markedly.

These data are too few to warrant firm conclusions but the data do suggest that the arterial systems of Squalus acanthias function as simple pressure/volume systems which are little affected by vasomotor activity. This evidence indicates a need for further research on the vasomotor control of the circulation in this species.

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1969 #28

TOTAL BODY PERFUSION OF S. acanthias USING A MEMBRANE LUNG

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Efforts to develop a technique of perfusing the gills of S. acanthias were described in 1962 by Peirce and Dabbs (Bull. MDIBL 5:19, 1965). Attempts to limit the perfusion to a portion of the fish proved to be too difficult because of blood leakage from cut surfaces. An additional problem was the poor gas permeability of the 0.5 mil Teflon ^{R} then available. A total body perfusion technique was developed to permit more precise analysis of a gill vascular reflex elicited when 2 to 5% CO_2 in air was equilibrated with the seawater perfusing the gills (Bull. MDIBL 8:35, 1968). A membrane of high permeability, MEM-213, manufactured by General Electric Corporation (Trans. Amer. Soc. Artif. Int. Organs 14:220, 1968) was available and made it possible to use a small artificial lung. The preparation was extremely satisfactory, being easily controlled and stable. Its use should simplify obtaining a variety of cardiovascular and metabolic data.

The apparatus and fish were arranged as shown in Figure 1. Donor fish were heparinized (500 units of aqueous heparin/kg) and bled from a needle in the dorsal aorta while gill perfusion