

VOLUME CHANGE AND VENOUS FUNCTION IN HAGFISHES

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EXTENDED ABSTRACT ONLY – DO NOT CITE

Central venous pressure is the major determinant of cardiac output in all vertebrate animals, through the Frank-Starling effect. Autonomic nervous control and the actions of circulating hormones then fine tune the heart's performance. In a "fish" circulation the blood returning to the heart has passed at least two vascular resistance beds in series and its kinetic energy is low. Venous pressures, therefore are low. The importance of *vis a fronté* filling of the heart, driven by negative pressures within the pericardial cavity, is thus particularly significant in teleost and elasmobranch fishes. Johnsson et al. (1996) demonstrated that even in the absence of a rigid pericardium cutting the connective tissues investing the portal heart of the hagfish *Eptatretus cirrhatus* changed heart rate.

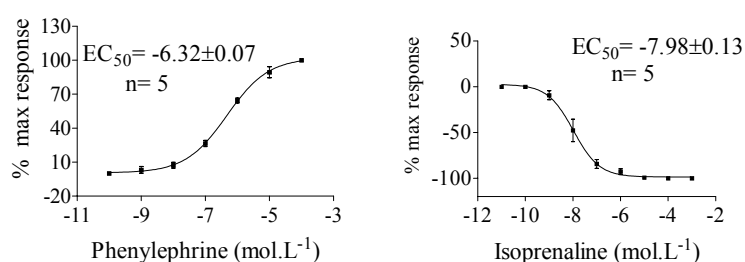


Fig. 1. Cumulative concentration-response curves, supra-intestinal vein.

Though smooth muscle is a small component in fish veins, there is sufficient data from teleosts, at least, to demonstrate the potential for active vasomotion in these vessels (Zhang et al., 1998). They are not merely passive conduit vessels. Hagfish veins react to a variety of pharmacological agents, including catecholamines (Fig 1).

Hagfishes are osmoconformers, with an ionic composition of their extracellular fluids which is little different from seawater. Their arterial blood pressures are the lowest of any chordate animal and venous pressures

are low, but positive. Pressures in the suprainestinal vein averaged 0.70 ± 0.12 cm H₂O and those in the posterior cardinal vein averaged 0.37 ± 0.08 cm H₂O (n = 15). Hagfishes are unlikely to experience hypertonic media, but may risk volume loading if they venture into estuaries or consume teleost fish in their diet. We used volume loading (90% seawater) and volume depletion (110%) seawater to stress the vascular system of *E. cirrhatus* and monitor changes in arterial and venous pressures *via* indwelling cannulae. In the absence of any passive compensating mechanisms or active volume regulation, we predicted that arterial and venous blood pressures would rise and remain at a value at least 10% greater than pre-loading and would decrease by at least 10% in dehydrated animals.

24 hours after transfer to 90% seawater dorsal aortic blood pressure was 12.94 ± 1.69 compared to a pre-treatment value of 14.45 ± 1.32 (n = 3). In the volume loaded animals there seemed to be an extremely rapid adjustment in pressures, with compensation occurring within the first three hours of osmotic challenge (Fig 2).

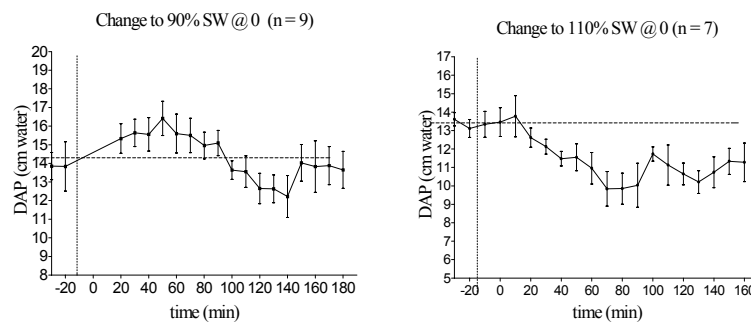


Fig. 2 Dorsal aortic pressure changes on transfer to 90% or 110% seawater.

Judged by their behavioural responses, hagfishes tolerated hydration better than they tolerated dehydration. They were much more active in 110% seawater, exhibiting knotting behaviour. Toop and Evans (1993) found that *Myxine glutinosa* were able to compensate for volume loading, but not for the volume decrease in 115% SW. 24 hours after transfer to 110% seawater mean dorsal aortic pressure was 11.43 cm H₂O compared to their 100% value of 13.38 ± 0.05 (n = 6). Pressures in the posterior cardinal vein also fell in animals exposed to 110% seawater. Given the variability in resting venous pressures and the difficulty of measuring them reliably, it might seem optimistic to expect to record a change with a 10% change in blood volume. However, the volume change should have its effect on the

stressed volume in the veins and therefore the predicted pressure change would be greater than 10%.

Blood volume as a percentage of body volume is greater in hagfishes than other chordates ((Forster et al., 2001) and the venous system is compartmentalised, with numerous separate sinuses. Arterial “pressure relief valves” were first described by (Cole, 1913). It is easy to envisage movement of blood out of the central circulation and into the sinus system in volume loaded animals as arterial pressures rise. It is more difficult to conceive of a system that restores blood volume once lost. That the blood volume is large will not buffer an osmoconforming animal from volume changes and there is evidence that blood osmotic pressure changes rapidly on hydration and dehydration.

These experiments were approved by the Animal Ethics Committee of the University of Canterbury.

References

- Cole, F. J. (1913). Monograph on the general morphology of the Myxinoid fishes, based on a study of *Myxine* - part 4 - On some peculiarities of the afferent and efferent branchial arteries of *Myxine*. *Trans. Roy.Soc.Edin.* 68: 215-230
- Forster, M. E., Russell, M. J., Hambleton, D. C. and Olson, K. R. (2001). Blood and extracellular fluid volume in whole body and tissues of the Pacific hagfish, *Eptatretus stouti*. *Physiol. Biochem. Zool.* 74: 750-756.
- Johnsson, M., Axelsson, M., Davison, W., Forster, M. E. and Nilsson, S. (1996). Effects of preload and afterload on the performance of the in situ perfused portal heart of the New Zealand hagfish (*Eptatretus cirrhatus*). *J. Exptl. Biol.* 199: 401-405.
- Toop, T. and Evans, D.H., (1993) Whole animal volume regulation in the Atlantic hagfish, *Myxine glutinosa*, exposed to 85% and 115% sea water. *Bull. Mt. Desert Island Biol. Lab.* 32: 98-99.
- Zhang, Y.T., Weaver, L., Ibeawuchi, A. and Olson, K.R. (1998) Catecholaminergic regulation of venous function in the rainbow trout. *Am. J. Physiol.* 274: R1195-R1202.

