THE EFFECT OF ADRENALINE ON RENAL VASCULATURE AND FILTRATION CHARACTERISTICS IN THE ISOLATED PERFUSED GLOMERULUS OF THE ATLANTIC HAGFISH, MYXINE GLUTINOSA

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Introduction

The hagfish Myxine glutinosa (Cyclostomata) is from the phylogenetic point of view a very early vertebrate whose endocrine system may differ from higher vertebrates in that e.g. prolactin and a renal renin-angiotensin system (juxtaglomerular cells, macula densa) seem to be missing (Aler et al., Gen. Comp. Endocrinol. 16:498-503, 1971; Wilson, Endocrine Reviews 5:45-61, 1984). Although the presence of catecholamines has already been demonstrated in various organs (e.g. heart and kidney) of Myxine (Euler and Fänge, Gen. Comp. Endocrinol. 1: 191-194, 1961), little attention has been paid to the effects of catecholamines on systemic blood pressure and kidney function in the hagfish. The aim of the present study was to investigate (1.) whether adrenaline has any effect on the renal vasculature and (2.) whether adrenaline changes glomerular filtration characteristics. The pressure controlled microperfusion of single isolated glomeruli made possible the simultaneous measurement of single nephron glomerular filtration rate (SNGFR), ultrafiltration pressure (P_{UF}), filtration fraction (FF) and ultrafiltration coefficient (Kf) under well defined conditions (Elger & Stolte, Bull. MDIBL 24:56-57, 1984).

Materials and Methods

Experiments were carried out on 12 hagfish (weight 40-75 g, length 33-39 cm). The fish were maintained in a container with filtered and aerated seawater at 4-5 ^{o}C. Before the operation, the fish were anaesthetized with propylen-phenoxetol (4 ml/2 l seawater).

During the whole preparation the gills and the body of the animals were chilled with aerated seawater. A double-barrelled cannula inserted into the dorsal aorta made possible a simultaneous perfusion and recording of the pressure at the tip of the cannula (Elger & Stolte, ibid.). Pressure on the epithelial side of the glomerular capillary was measured by the insertion of a PP10 catheter proximal in the archinephric duct (AND). Another catheter inserted distally allowed the measurement of the SNGFR by reading the advance of the ultrafiltrate. The arrangement of catheters, cannula and glomerulus was transferred into a small cooled chamber which contained a colloidfree Ringer's solution (Riegel, J. Exp. Biol. 73:261-277, 1978) identical to the perfusate.

Perfusion pressure was held on levels of 8-12 cm H_2O by regulation of the perfusate flow rate. After a steady ultrafiltrate flow was measured the bathing medium was exchanged for Ringer's solution to which adrenaline (Suprarenin, Hoechst) had been added to a concentration of $9x10^{-5}$ M. P_{UF} was calculated as the difference between the pressure in the perfused dorsal aorta and pressure in the AND. Filtration fraction (FF) was obtained by comparison of perfusate flow and SNGFR.

Results

In isolated glomeruli perfused at constant flow rate, adrenaline caused a significant ($P < 0.001$) increase of P_{UF} by 60% from 5.33 ± 0.33 cm H_2O to 8.85 ± 0.66 cm H_2O ($\bar{x}$ ± S.E.). On an average 3 minutes elapsed before a change of the ultrafiltration pressure could be recorded. The pressure in the archinephric duct remained constant throughout all experiments.

Concomitant to the increased P_{UF}, SNGFR was enhanced from 63.95 ± 21.9 nl/min to 114.14 ± 34.9 nl/min ($P < 0.01$). Due to this parallelism, Kf which is the ratio of SNGFR and P_{UF} only showed an insignificant alteration from 0.27 ± 0.1 to 0.32 ± 0.1 $nl \cdot s^{-1} \cdot mmHg^{-1}$. Filtration fraction rose from 14.36 ± 5.1 % to 25.48 ± 7.2 % ($P < 0.005$).

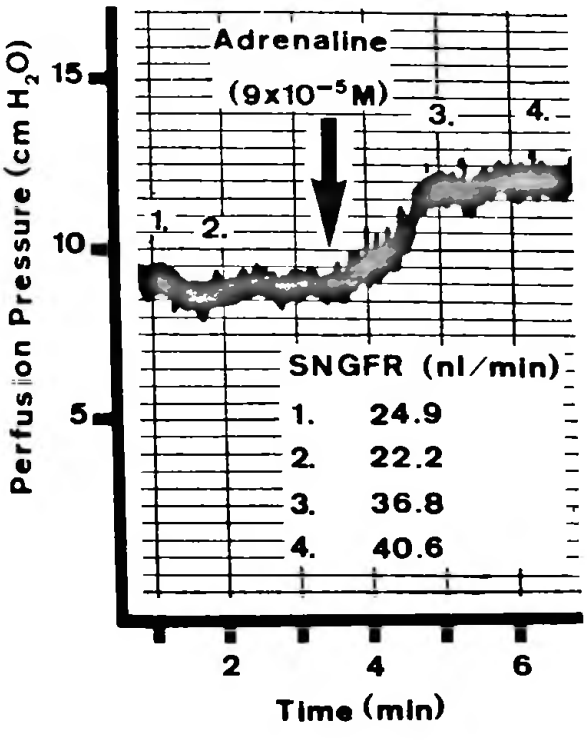

Figure 1. The effect of adrenaline on dorsal aortic blood pressure and SNGFR in the isolated perfused glomerulus of Myxine.

Discussion

Microperfusion of isolated glomeruli was performed with pressures of 5 to 11 cm H_2O which is well within the range of dorsal aortic blood pressure recordings in Myxine reported previously (Johansen, Biol. Bull. Mar. Biol. Lab. Lancaster 118:289-295, 1960; Chapman et al., Circulation Res. 12 (5), part 1, 1963; Stolte & Eisenbach, Bull. MDIBL 13:120-121, 1973; Carrol & Opdyke, Amer. J. Physiol. 243:R65-R69, 1982). Physical disturbances of the preparations during the changes of bath solution were negligible since no alterations were observed in the pressure recordings of dorsal aorta and archinephric duct.

After the addition of adrenaline, marked increases in dorsal aortic pressure were manifested indicating constriction of dorsal aorta and/or renal vasculature. It may be concluded from the increased SNGFR that efferent arterioles were constricted thereby increasing intraglomerular capillary pressure. The finding that SNGFR increased parallel to the increase in P_{UF} while glomerular perfusate flow rate was constant supports the previously described concept of a pressure dependent filtration process in Myxinoids (Alt et al., J. Exp. Biol. 91:323-330, 1981). In comparison to reported inconsistent effects of catecholamines on the intestine and gallbladder (Holmgren & Fänge, Marine Biol. Letters 2: 265-277, 1981) the effects of adrenaline on vasculature and kidney were quite stable and reproducible.

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