JOURNAL OF PHYSIOLOGY AND PHARMACOLOGY 1997, 48, 2, 179—184

R. ZIĘCINA, P. ABRAMCZYK, A. LISIECKA, J. PRZYBYLSKI

THE ADRENAL-RENAL VASCULAR CONNECTION CONTRIBUTES TO INCREASE IN RENAL VASCULAR RESISTANCE DURING AN EXPERIMENTAL HYPOTENSION IN THE RAT

Department of Physiology, Medical Academy, Warsaw, Poland

The adrenal vascular connection (ARVC) was described for the first time in the cat by Cow (1914) and by other authors in the dog, rat, rabbit and humans. The aim of the present study is to investigate the role of above connection in regulation of renal vascular resistance (RVR), and renal blood flow (RBF) during decrease in blood pressure in the rat. Animals were divided into three groups. In the first group, mean arterial pressure (MAP) was unchanged. In the second and the third group MAP was maintained at 50 mmHg. In addition in the third group, an alpha adrenergic receptor blockade was produced with intravenous infusion of phentolamine. After stabilisation of RBF, in all groups, the tissue between the adrenal gland and the kidney was cut. RBF and MAP were measured and recorded. In the first and the third group, the elimination of ARVC neither influenced RBF nor RVR. In the second group the elimination of ARVC caused increase in RBF and decrease in RVR ($p<0.01$). Results of the present study provide the evidence that catecholamines reaching the kidney, directly from the adrenal gland through ARVC, during the severe hypotension are responsible for reducing of renal blood flow and increase in renal vascular resistance in the rat.

K e y w o r d s: *Renal blood flow, renal vascular resistance, hypotension, adrenal-renal vascular connection*

INTRODUCTION

An abrupt decrease in mean arterial blood pressure leads to an immediate compensatory peripheral vasoconstriction including the vasculature of kidneys (1—3). This prompt reflex activation of sympatho-adrenal system causes a disproportionally greater reduction in renal blood flow than can be accounted for the diminished cardiac output alone (1). Activation of renal sympathetic nerves is an important compensatory mechanism responsible for the maintenance of vascular volume by the decrease in glomerular filtration rate and sodium retention (2, 4, 5). Interestingly enough vasoconstriction in

kidneys occurs even after their denervation and persists for several minutes after returning blood pressure to the normal level (6). The prolonged diminution of renal blood flow in response to brief hypotension, caused by an episode of induced atrial fibrillation in the dog, does not depend on renal sympathetic efferent nerves, and is evoked by catecholamines reaching the kidney directly from the adrenal medulla *via* adrenal-renal vascular connection (ARVC) (1, 6).

The direct vascular connection between the adrenal gland and the kidney was described for the first time in the cat by Cow (1914) and by other authors in the dog, rat, rabbit and humans (1, 7—10).

The aim of the present study is to investigate the role of above connection in regulation of renal vascular resistance and renal blood flow during decrease in the blood pressure in the rat.

MATERIALS AND METHODS

Experiments were performed on 28 male Wistar rats weighing 300—400 g obtained from Medical Academy animal house (Warsaw, Poland). Four rats were kept per standard laboratory cage, at controlled 12 hour dark and light phases, with food and water available *ad libitum*.

The anaesthesia was induced with chloral hydrate (Sigma-Aldrich Chemie GmbH, Deisenhofen, Germany) at the dose of 0.36 g/kg b.w. i.p. The anaesthesia was maintained intravenously by additional doses of chloral hydrate as necessary. The trachea was cannulated, rats were paralysed with pancuronium (Pavulon, Organon Teknika B.V., Boxtel, Holland) at the dose of 0.005 mg/kg b.w. i.v. and artificially ventilated using Harvard pump (L) for small animals. Ventilation was adjusted under control of arterial blood gasometry (Blood Gas System — AVL 995 Hb) to maintain values of pH, pCO_2 and pO_2 within normal limits. Mean arterial blood pressure (MAP) was monitored using pressure transducer (MCK-4011, Poland) attached to a cannula inserted into the femoral artery. The left femoral vein was cannulated for drugs and fluids administration. Rectal temperature was maintained at 37.5°C by means of the thermostatically controlled heating blanket.

After laparotomy, the left renal artery and vein were dissected free and the kidney was denervated by cutting renal nerves which was later followed by brushing of the kidney hilum with 10% alcohol solution of fenolum. Then for measurement of renal blood flow (RBF) the flow-probe of Doppler-flowmeter (Transonic-System, USA) was placed on the left renal vein. Animals were divided into three groups. In the first group (n = 8) (I), MAP was unchanged. In the second and the third group (n = 10) (II, III), MAP was maintained at 50 mmHg by a barostat container filled up with heparinized isotonic NaCl solution. The cannula connecting the barostat container was inserted into the carotid artery. The barostat container was placed 65 cm above the heart. In the group III, an alpha adrenergic receptor blockade was produced with intravenous infusion of phentolamine (Regitin, Ciba-Geigy, Switzerland) (0.2 mg/kg b.w. bolus followed by continuous infusion of 0.02 mg/min/kg b.w. up to the end of experiment). After stabilisation of RBF, in all groups, the tissue between the adrenal gland and the kidney was cut. RBF and MAP were measured and recorded using chart recorder (Mingograph, Siemens).

Renal vascular resistance (RVR) was calculated as mean arterial pressure (mmHg)/ renal blood flow (ml/min/100 g b.w.), and expressed as RRU — Renal Resistance Units. RBF was also calculated per 100 g of body weight.

Student's paired t-test was used to compare results with the respective controls. Statistical comparision between groups was performed by Anova analysis of variance. A value of $p<0.05$ was accepted as significant. Values are presented as means ± SEM (Standard Error of the Mean).

RESULTS

Elimination of ARVC did not influence RBF (1,73 ± 0.07 vs. 1.72 ± 0.08 ml/min/100 g b.w.) nor RVR (49.6 ± 2.1 vs. 50.3 ± 2.5 RRU) in the group I.

In the group II, a decrease of blood pressure significantly reduced RBF (from 1.75 ± 0.03 to 0.69 ± 0.04 ml/min/100 g b.w., $p<0.01$) and increased RVR (from 51.3 ± 3.1 to 68.2 ± 4.5 RRU, $p<0.01$). The elimination of ARVC caused increase in RBF (from 0.69 ± 0.04 to 0.87 ± 0.05 ml/min/100 g b.w., $p<0.01$) and decrease in RVR (from 68.2 ± 4.5 to 53.6 ± 3.1 RRU, $p<0.01$). In the group III, a decrease of blood pressure significantly reduced RBF (from 1.74 ± 0.04 to 0.67 ± 0.04 ml/min/100 g b.w., $p<0.01$) and increased RVR (from 48.7 ± 4.6 to 72.0 ± 5.4 RRU, $p<0.01$). A phentolamine administration increased RBF (from 0.67 ± 0.04 to 0.88 ± 0.06 ml/min/100 g b.w., $p<0.01$) and decreased RVR (from 72.0 ± 5.4 RRU to 51.9 ± 2.9 RRU). The elimination of ARVC neither influenced RBF (0.88 ± 0.06 vs. 0.87 ± 0.05 ml/min/100 g b.w.) nor RVR (51.9 ± 2.9 vs. 55.0 ± 2.7 RRU).

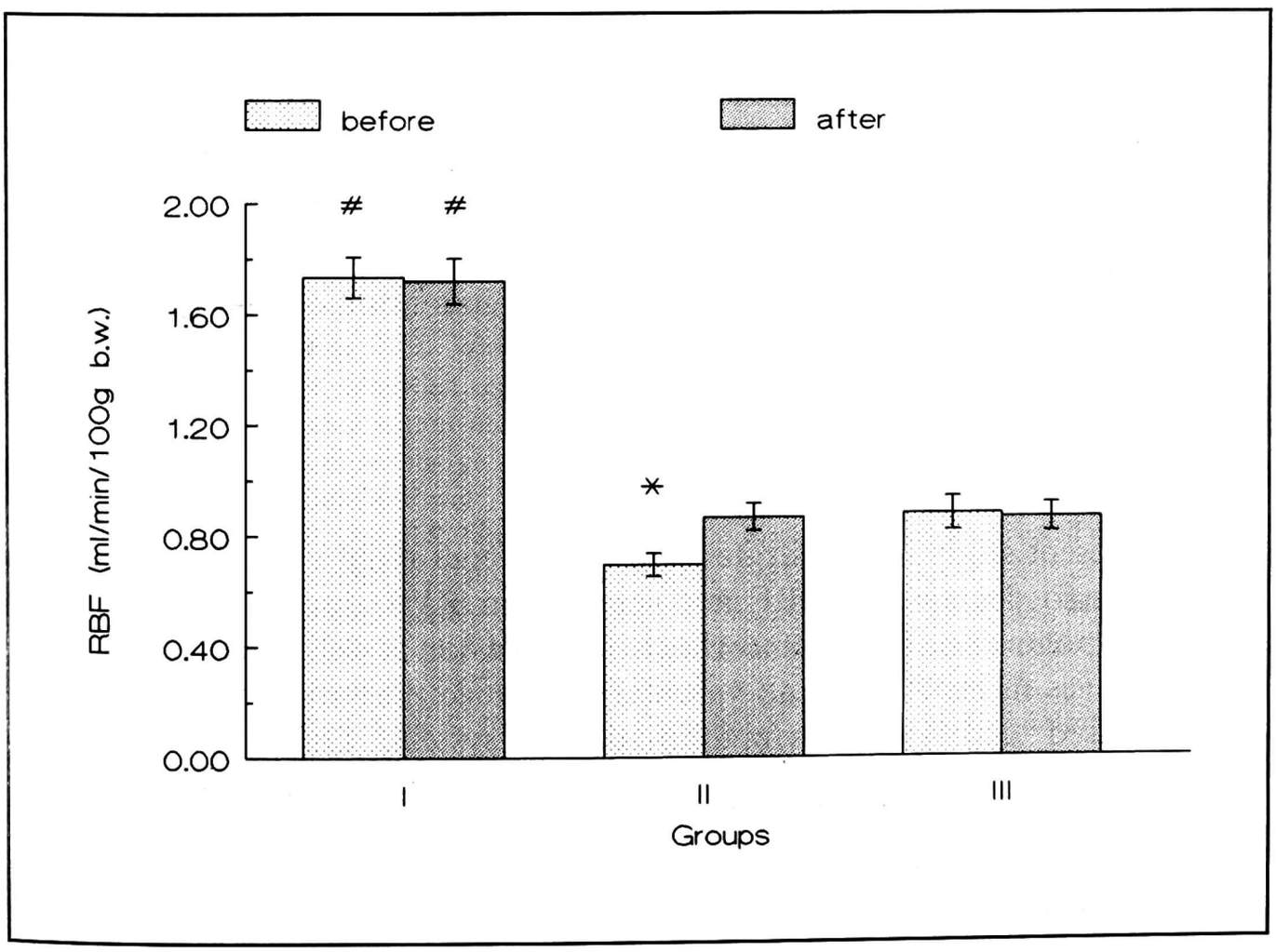

Fig. 1. Renal blood flow (RBF) before and after elimination of ARVC in the control group (I), during hypotension (II), during hypotension and alpha receptors blockade (III). Means ± SEM, # — significance as compared to groups II and III, $p<0.01$; * significance as compared to all other results, $p<0.01$.

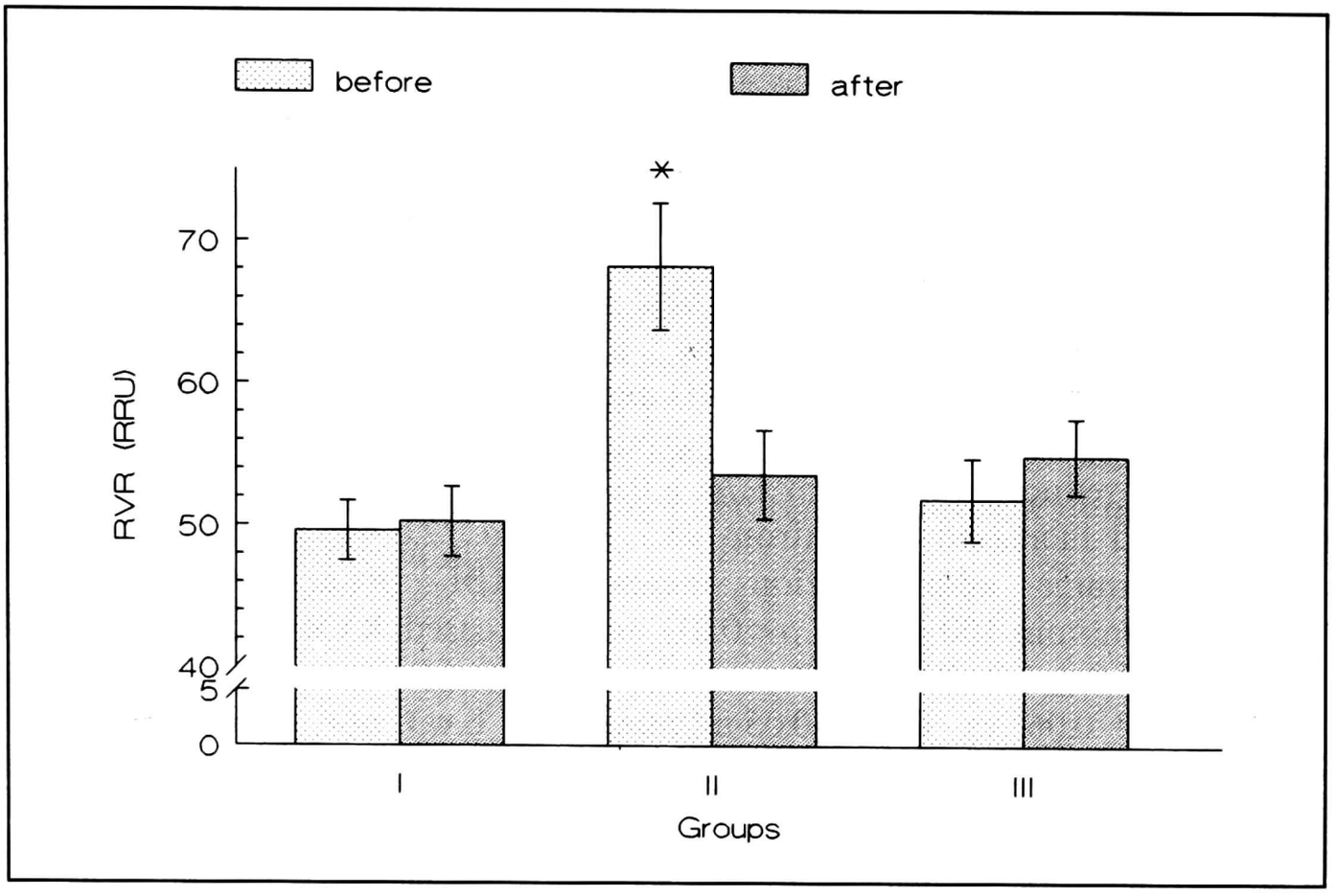

Fig. 2. Renal vascular resistance (RVR) before and after elimination of ARVC in the control group (I), during hypotension (II), during hypotension and alpha receptors blockade (III). Means ± SEM, * significance as compared to all other results, $p < 0.01$.

Changes in RBF and RVR before and after elimination of ARVC are shown in *Fig. 1* and *2.*

DISCUSSION

The present study demonstrates that the adrenal-renal vascular connection contributes to decrease in RBF and increase in RVR during experimentally induced hypotension. The haemorrhagic hypotension is well known to produce reflex changes in heart rate and vascular resistance that are related in part to the increased activity of sympatho-adrenal system. During hypotension, prompt increase in concentration of both epinephrine and norepinephrine in blood is observed (11). The increase in catecholamines blood concentration represents adrenomedullary secretion as well as overflow from sympathetic nerves. It was shown that after reducing blood pressure to the level of 50 mmHg, as applied in the present study, the rise of epinephrine in circulating blood was more pronounced as compared to norepinephprine (11, 12). These findings point to the pivotal role of adrenal medulla as a source of catecholamines, in this model of hypotension.

Recent studies revealed that sympathetic nerves activity (SNA) do not increase, and may actually decrease, during the severe hypotension induced by haemorrhage (13—15). Victor *et al.* (14) described decrease in renal SNA and increase in adrenal SNA at low values of blood pressure in the dog.

Histochemical studies showed that kidney is richly endowed with sympathetic adrenergic nerves, particularly in the renal cortex (3), which according to Victor *et al.* (14) show decreased activity in the severe hypotension. Nevertheless blood flow to the superficial cortex is significantly reduced after haemorrhage — especially in severe haemorrhage (16). This is consistent with the results of Katholi *et al.* (17) who found that vessels of ARVC reach the superficial renal cortex.

Results of the present study provide evidence that catecholamines reaching the kidney directly from the adrenal gland through ARVC, during severe hypotension are responsible for decrease in renal blood flow, and increase in renal vasular resistance in the rat.

Acknowledgement: P. Abramczyk is a fellow of Foundation for Polish Science.

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R e c e i v e d: December 21, 1996
A c c e p t e d: April 8, 1997

Author's address: R. Zięcina, Department of Physiology, Medical Academy, Krakowskie Przedmieście 26/28 Str., 00-325 Warsaw, Poland.