SCRIPTA MEDICA (BRNO) – 74 (1): 19–24, *February 2001*

RELATIONSHIP BETWEEN ARTERIAL BLOOD PRESSURE AND CAROTID BLOOD FLOW IN ESSENTIAL HYPERTENSION TREATED WITH ENALAPRIL

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A b s t r a c t

The curve of the relationship between the mean arterial pressure and the mean carotid blood flow in hypertensives is shifted to higher values. The aim of the present paper was to study the relationship between the mean arterial pressure and the mean carotid blood flow in patients with essential hypertension treated with enalapril. A group of untreated subjects with essential hypertension, a group of patients with essential hypertension after 3 months of enalapril treatment and a control group of age-matched normotensives were investigated. Our results showed that the slope of the carotid blood flow-blood pressure relationship did not differ between the normotensive subjects and the patients with essential hypertension treated with enalapril. The slope of the carotid blood flow-blood pressure relationship was shifted to the right in the untreated hypertensives.

K e y w o r d s

Carotid blood flow, Arterial blood pressure relationship, Essential hypertension, Enalapril therapy

INTRODUCTION

Stroke is one of the most feared diseases. The World Health Report states that cardiovascular diseases currently account for 30% of deaths worldwide *(1)*. The relationship between blood pressure and cerebrovascular disease has been described and the risk of stroke related to the standard diastolic and systolic blood pressure in Eastern and Western populations *(2,3)*. Essential hypertension presents an increased risk of stroke. The haemodynamics of cerebral vessels in patients with essential hypertension has frequently been studied but the relationship between blood pressure and blood flow has not been fully clarified. Previous studies have shown that, in hypertensives, the curve of the relationship between the mean arterial pressure (MAP) and the mean blood flow (MBF) has been shifted to higher values *(4)*. The aim of the present paper is to study the relationship between MAP and MBF in patients with essential hypertension treated with enalapril, an angiotensin converting enzyme (ACE) inhibitor.

MATERIALS AND METHODS

The patients included a group of non-treated subjects with essential hypertension (EH; n=10; mean±SD age, 49±11 years; systolic/diastolic blood pressure, 155±23/99±12 mmHg) and a group of patients with essential hypertension after 3 months of treatment with enalapril at 20mg per day in a morning dose (EH E; n=12; mean±SD age, 50±11 years; systolic/diastolic blood pressure, 155±10/99±5 mmHg before therapy). The diagnosis of essential hypertension (EH) was established by detecting elevated blood pressure (more than 140/90mmHg) by sphygmomanometer measurement on three different occasions within one month. The possibility that the patients had secondary causes of hypertension was excluded by clinical examination. A control group consisted of subjects selected from a large group of non-hypertensive individuals (C; n=10, age-matched controls). The study was approved by the Ethics Committee of the Masaryk University in Brno and all subjects gave their written informed consent.

Blood pressure was continuously recorded in finger arteries for 5 minutes by the Peňáz non-invasive, volume-clamp method (Finapres, Ohmeda).

All three groups were studied in the supine position, at a neutral ambient temperature (21±l °C). An inflatable cuff was placed on each thigh of all subjects. After a 20-minute rest, the cuff pressure was rapidly increased to 180 mmHg and kept constant for 5 min, bringing about a complete circulatory arrest in both lower extremities. After this 5-minute occlusion, the cuff pressure was lowered abruptly to 60 mmHg, so that an abnormal venous return from the lower limbs was avoided. The abrupt release of occlusion elicited an abrupt decrease in MAP of 10-20 mmHg.

Blood pressure (BP) and blood flow in the carotid artery (MAF) were measured simultaneously, before and after cuff release. Heart rate was evaluated from pressure recordings, beat to beat. Blood flow was determined using an ultrasonic Doppler velocimeter *(5).*

The results were statistically analysed and presented as mean values with standard deviations. Statistical significances of the differencies observed were calculated using the ANOVA and Wilcoxon tests; only *P* values lower than 0.05 were considered to be significant.

RESULTS

The abrupt change of occluding cuff pressure from 180 mmHg (or 20 mmHg above systolic pressure) to 60 mmHg produced a rapid decrease in MAP. The minimum MAP was reached in the first 3 sec after release. Both pairs of MAP and MBF values immediately before the release of occluding pressure (MAPb, MBFb), minimum MAP and MBF after the release (MAPa, MBFa) and the slope of the flow-pressure relationship (MBFb-MBFa)/(MAPb-MAPa) were evaluated. The results (mean value±SD) are presented in *Table 1* and *Fig.1*.

The slope of the flow-pressure relationship remained constant in all three groups, only the line of this relationship in non-treated hypertensives was shifted to the right ($p<0.05$). This shift was reversed by enalapril treatment, as indicated by the position of the line expressing the relationship in group EH E.

DISCUSSSION

The pressure-flow relationship in the carotid artery reflects structural changes in the arteries of hypertensives, caused by high arterial pressure *(6).* Structural changes in the resistance vessels improve tolerance to high pressures but, on the other hand, they impair tolerance to hypotension, presumably because the autoregulatory vasodilatation is compromised by wall thickening and luminal

Table 1

The values of MAP and MBF immediately before the release of occluding pressure (MAPb, MBFb) and minimum MAP and minimum MBF values after the release (MAPa, MBFa) and the slope (ml.mmHg/min) of the flow-pressure relationship (MBFb-MBFa)/(MAPb-MAPa).

	MAPb	MAPa	MAFb	MAFa	Slope
C	94±7	78±9	316±31	242±33	4.6±2.0
EH E	96±8	84±11	308±28	259±42	4.1±1.8
EH	117±18*+	103±17*+	329±48	258±46	5.1±2.5

MAP, mean arterial pressure: b, before (MAPb),and a, after (MAPa) release of occluding pressure; MBF, mean blood flow: b, before (MBFb) and a, after (MBFa) release of occluding pressure; C, controls; EH E, hzpertensives treated with enalapril; EH, hypertensives without treatment; +, EH versus C, $P<0.05$; *, EH versus EH E, $P<0.05$

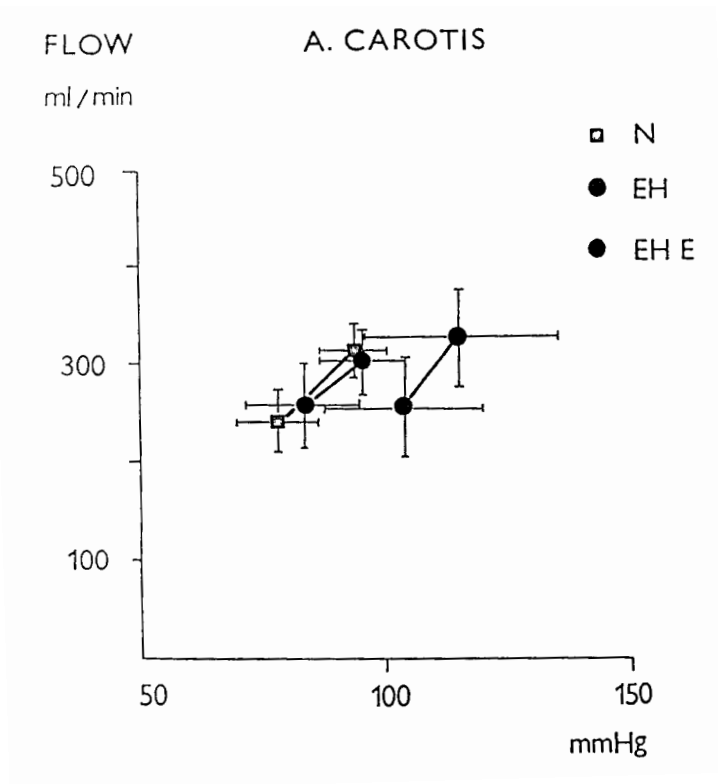

Fig. 1
The plot of the carotid blood flow-blood pressure relationship (mean values SD) in normotensive subjects (N), in patients with essential hypertension (EH) and in patients with essential hypertension treated with enalapril (EH E).

narrowing. A shift of the lower limit of autoregulation to higher pressure is proportional to the severity of hypertension. The clinical consequence of the shift in the lower limit of autoregulation means that, if blood pressure of a hypertensive patient is rapidly lowered to the normotensive levels, the cerebral blood flow will fall, possibly causing ischaemic brain damage *(7).* Additionally, we observed that autoregulation in cerebral circulation did not function properly in non-treated hypertensive subjects. Instead of restoring blood flow after the decrease in blood pressure, the cerebral blood flow remained at the low level attained after the initial decrease until blood pressure returned to its normal value *(4).*

In view of the observations described above, our results on the normalization of common carotid artery pressure-flow relationship during enalapril treatment and the decrease in blood pressure in untreated hypertensives are very important findings. The method used in the present study also enables us to control the effect of treatment on the resistance vessels and, therefore, to evaluate the effect of antihypertensive treatment better than by measurement of blood pressure alone, because this varies and cannot always be a good indicator of the severity of disease, as shown, for instance, in subjects with „white coat“ hypertension.

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VZTAH MEZI KREVNÍM TLAKEM A PRŮTOKEM V KAROTIDĚ U ESENCIÁLNÍ HYPERTENZE LÉČENÉ ENALAPRILEM

S o u h r n

Křivka vztahu mezi středním arteriálním tlakem a karotickým průtokem je posunuta u hypertoniků k vyšším hodnotám krevního tlaku. Cílem této práce je analýza vztahu mezi středním arteriálním tlakem a karotickým průtokem u pacientů s esenciální hypertenzí léčených ACE inhibitorem enalaprilem. Vyšetřili jsme skupinu neléčených pacientů s esenciální hypertenzí, skupinu pacientů po léčbě ACE inhibitorem enalaprilem po dobu 3 měsíců a kontrolní skupinu věkově odpovídajících normotoniků. Naše výsledky ukázaly, že sklon křivky vztahu mezi středním arteriálním tlakem a karotickým průtokem se neliší u normotoniků a u pacientů s esenciální hypertenzí léčených ACE inhibitorem enalaprilem. sklon křivky vztahu mezi středním arteriálním tlakem a karotickým průtokem u neléčených hypertoniků je posunut doprava.

A c k n o w l e d g e m e n t s

This study was supported by a grant CEZ J03/98:100004. from the Czech Ministry of Education.

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