Evidence for peripheral vascular involvement in mild elevation of blood pressure in man

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Summary

1. Cardiac output at rest, intra-arterial blood pressure and hand blood flow at maximal vasodilatation were studied in two groups of 18–25-year-old men: forty-four with mild blood pressure elevation were referred from a military enlistment centre, and twenty-nine normotensive volunteers were mainly recruited from the same enlistment centre.

2. The study group was characterized by a significantly higher cardiac index at rest, and a significantly higher blood flow resistance in the hand at maximal vasodilatation than the control group, indicating the presence of structural modifications in the resistance vessels of patients with mild blood pressure elevation.

3. The tendency to increased vascular resistance in the blood vessels of the hand at maximal vasodilatation was more pronounced in patients with a normal cardiac index than in those with a high index. This suggests inclusion in the study group of tense, anxious individuals with an elevated cardiac index but otherwise normal circulation, but does not exclude the possibility that these patients may develop structural changes later on.

Key words: blood pressure, cardiac output, hand blood-flow, hypertension, peripheral vascular resistance, plethysmography.

Introduction

A hyperkinetic circulation at rest with an elevated cardiac output has repeatedly been found to be a group characteristic of patients with latent, borderline arterial hypertension (Widimský, Fejfarová, Fejar, 1957; Eich, Peters, Cuddy, Smulyan & Lyons, 1962; Bello, Sevy & Harakal, 1965; Finkelman, Worcel & Agrest, 1965; Sannerstedt, 1966; Julius & Conway, 1968; Lund-Johansen, 1968; Frohlich, Kozul, Tarazi & Dustan, 1970; Safar, Weiss, London, Frackowiak & Milliez, 1974).

Furthermore, the calculated systemic vascular resistance in such patients is relatively elevated compared with normotensive individuals (Lund-Johansen, 1968; Sannerstedt, 1969; Julius, Pascual, Sannerstedt & Mitchell, 1971; Safar, Weiss, Levenson, London & Milliez, 1973).

The high cardiac output at rest in latent, borderline arterial hypertension may be interpreted in two ways. High output is either something which characterizes patients with early essential hypertension, or at least some of them, or else the hyperkinetic circulation in latent, borderline hypertension is due to inclusion in the material of tense, anxious and hyperkinetic individuals with an otherwise normal circulation.

To evaluate this systemic haemodynamics at rest in the supine position and peripheral haemodynamics during physiologically induced maximal vasodilatation were studied in a group of young men with mild blood pressure elevation and compared with the results from carefully matched control subjects.

Methods

Subjects

Forty-four young men, aged 19–22 years, were referred from a military enlistment centre after
having presented with auscultatory blood pressures \( \geq 150 \text{ mmHg systolic or } \geq 90 \text{ mmHg diastolic} \) at a highly standardized, routine medical examination. Further requirements were systolic blood pressures at two subsequent follow-ups of \( \geq 140 \text{ mmHg} \). None had any indication of organic changes in the cardiovascular system or kidneys.

Twenty-four male volunteer subjects, aged 18–20 years, were recruited from the same pool of young men at the military enlistment centre and formed a reference group. All of them had auscultatory blood pressures \( \leq 130/80 \text{ mmHg} \) at two separate examinations. In addition, five male blood donors aged 19–22 years and fulfilling the same blood pressure criteria were included as control subjects.

The study protocol was approved by the Ethical Committee of the University, and informed consent was obtained from all subjects participating in the study.

**Procedure**

The subjects reported at the laboratory in the morning after having eaten a light breakfast. A polythene catheter was introduced percutaneously under local anaesthesia into one brachial artery, and another catheter was placed in a subclavian vein via percutaneous puncture of an antecubital vein.

After 45 min rest in the recumbent position intraarterial blood pressure, heart rate and cardiac output were measured repeatedly during 1 h of continued rest, pressor transducer recordings (Elema-Schönander EMT 35) and a dye-dilution technique (Cardiogreen, Cardiognost Atlas) being used. The average figures from this series of recordings are presented.

Subsequently, the subjects were transferred to another room in the same laboratory for determinations of peripheral haemodynamics during a state of physiologically induced maximal vasodilatation. After a period of general heating under an electric arc, and local heating of both hands in water-filled hand plethysmographs at a temperature of \( 43^\circ \text{C} \), arterial occlusion was applied to both arms and the subjects were asked to exercise their hands until exhaustion. Immediately after release of the occlusion hand blood flow and electrically integrated mean intraarterial blood pressure were determined (Sivertsson, 1970). The average value from three determinations of the hand blood flow at maximal vasodilatation in

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**Fig. 1.** Differences in systemic and peripheral haemodynamic findings between forty-four young men with mild blood pressure elevation, and twenty-nine normotensive control subjects. CI = cardiac index; BP_{La} = mean intra-arterial blood pressure; \( R_{\text{min}} \) = resistance in hand blood vessels at maximum dilatation; n.s. = not significant.
the catheter-free side was used for statistical calculations. The resistance in hand blood vessels at maximal vasodilatation was derived in arbitrary units, as the quotient between the mean brachial arterial blood pressure (mmHg) and the calculated hand blood flow (ml min⁻¹ 100 ml⁻¹ of tissue).

Student’s t-test was used for statistical analysis of differences between the groups.

Results
In addition to a significantly raised intra-arterial blood pressure, the patients with mild blood pressure elevation also had a significantly higher cardiac index at rest in recumbency compared with the controls (Fig. 1). However, the cardiac index was not generally elevated among the subjects in the study group, many of whom had values well within the normal limits.

Blood flow resistance in the hand at maximal vasodilatation was significantly higher in the study group than in the control group (Fig. 1). Subdivision of patients into those with a cardiac index above the control mean value ± 1 SD (i.e. a hyperkinetic group), and those with a cardiac index below the control mean value ± 1 SD (i.e. a normokinetic group), disclosed that the tendency to increased vascular resistance in the blood vessels of the hand at maximal vasodilatation was significantly increased in the normokinetic group, whereas the corresponding value in the hyperkinetic group was not different from that of the control subjects and significantly lower than in the normokinetic group (Fig. 1).

Discussion
The present results once again confirm the presence of hyperkinetic circulation at rest as a characteristic group finding in subjects with asymptomatic blood pressure elevation. The study also shows that an increased vascular resistance in the hand blood vessels during a state of induced maximal vasodilatation can already be demonstrated in young men with only very mild blood pressure elevation, compared with carefully matched control subjects. This suggests the occurrence of restrictive changes in the peripheral vascular bed which cannot be overcome by most potent physiological stimuli, not only in cases of established arterial hypertension (Sivertsson, 1970), but even in what may be assumed to be the very early stages of hypertensive cardiovascular disease.

Thus it seems probable that patients with latent, borderline arterial hypertension exhibit not only a hyperkinetic circulation at rest, with an elevated cardiac index, but also an increased vascular resistance in the hand blood vessels at maximal vasodilatation. However, the tendency to an increased vascular resistance is more pronounced among individuals with a normokinetic circulation than in hyperkinetic persons. This might in fact indicate inclusion of tense, anxious individuals, who present at the investigation with an elevated cardiac index, but who otherwise have a normal circulation. If this were so, it might also indicate that hyperkinetic circulation does not play a dominant role in the development of true hypertensive cardiovascular disease. However, the present results in no way exclude the possibility that the hyperkinetic patients may in time develop restrictive vascular changes typical of hypertensive cardiovascular disease. Only long-term follow-up studies will provide an answer to this question.

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References

