The Antagonism of Potassium and Catecholamines on the Vascular Tone of Isolated Arterial Segments

Potassium ions are released by exercising muscle fibres and their concentration in the venous outflow is measurably increased within a few seconds[1,2]. Furthermore it is known that a small increase in the potassium concentration dilates arteries – proved on limb preparations and by our own investigations on isolated arterial segments[3–5]. Therefore one can assume that potassium might be one of the agents decreasing arterial tone during muscular activity.

Noradrenaline (NA) or sympathetic stimulation are known to increase arterial tone in vivo as well as in vitro. But muscle blood flow increases during exercise in spite of the overall increased sympathetic activity[6,7]. In functional hyperemia, local vasodilatators suppress the vasoconstriction induced by adrenergic compounds as well as by sympathetic stimulation[8–10]. The mechanism of this inhibition is not yet clarified.

For this reason it is of interest to investigate the response pattern of arteries during simultaneous application of potassium and catecholamines. Different and controversial results have been reported concerning the simultaneous action of potassium and adrenaline[11,12]. In this study we have attempted to analyse the reaction of isolated arterial segments during simultaneous or successive administration of the two opposing agents.

Experiments were carried out on isolated segments of bovine facial arteries, which were mounted in a chamber at 37 °C. One end of the segment was connected with a pressure transducer (Schwarzer). After filling with Tyrode solution, the other end of the artery was closed and the pressure was increased to 100 mmHg by means of a Boyle-Mariotte's device. Length tension of the arterial segment was adjusted to 20 g under the control of a mechano-electrical transducer (Collins). The artery was allowed to adapt to the pressure of 100 mmHg and to the temperature of 37 °C for 30 min. Then the connection between the Boyle-Mariotte's device and the artery was interrupted and the inside pressure of the segment was recorded isometrically.

The vasoconstriction caused by NA rises sharply from the threshold concentration (5×10^{-7} g/ml, causing an increase in pressure of about 10–30 mmHg) to its maximum (5×10^{-6} g/ml, causing an increase in the pressure of about 150–200 mmHg). A slight additional increase in the potassium concentration at the height of the NA induced vasoconstriction inhibits the NA effect. The pressure increased by 5×10^{-6} g/ml NA is reduced by 6.34 mmole/l KCl to a value at and by 10 mmole/l KCl to a value below starting level (Figure A). In case of simultaneous application, the vasodilating effect of 6.34 mmole/l KCl dominates persistently over the vasoconstricting effect of NA (Figure B). After a vasodilatation induced by 6.34 mmole/l KCl, the additional application of NA (5×10^{-6} g/ml) sometimes evokes a slight vasoconstrictor response, but this effect could not be observed after a vasodilatation caused by 10 mmole/l KCl (Figure B). Similar results are obtained with adrenaline. Adrenaline has no dilating effect in our experiments.

The study shows that the vasodilating effect of potassium inhibits the vasoconstricting effect of catecholamines and that an increased potassium concentration sharply diminishes the responsiveness of isolated peripheral arteries of a muscular type to adrenergic compounds. Since active muscles release a substantial amount of potassium it cannot be denied that the increase in the potassium concentration might counterbalance the increased sympathetic activity. This assumption would correlate to a certain degree with the observation of a local functional sympatholysis during muscular exercise[8–10]. Further experiments on resistance vessels are necessary to prove that the reaction of the investigated peripheral artery is a common principle in muscle flow regulation.

Zusammenfassung. An isolierten Segmenten der Art. facialis (Rind) wurde der Innendruck (Anfangsdruck 100 mm Hg) fortlaufend isometrisch registriert, während die Aussenseite von Tyrode-Lösungen mit verschiedenem Kalium- und Catecholamingehalt umspült wurde. Die durch die Catecholamine (5×10 bis ^{7}–5×10^{-6} g/ml) induzierte Vasokonstriktion kann durch geringe Erhöhung der Kaliumkonzentration (von 2,8 auf 6,34 bis ca. 10 mmol) unterdrückt werden. Bei gleichzeitiger Applikation beider Substanzen setzt sich die dilatatorische Wirkung der K^+-Ionen durch.

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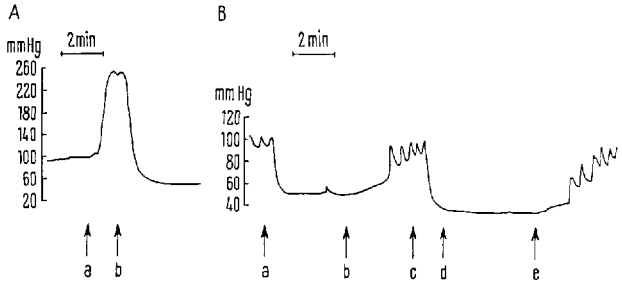

Arrows indicate the application of the different agents in Tyrode solution. A (a) NA 5×10^{-6} g/ml, (b) 10 mmole/l KCl and NA 5×10^{-6} g/ml. B (a) 6.34 mmole/l KCl and NA 5×10^{-6} g/ml, (b) 2.68 mmole/l KCl without NA, (c) 10 mmole/l KCl, (d) 10 mmole/l KCl and NA 5×10^{-6} g/ml, (e) 2.68 mmole/l KCl without NA; see text.

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