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Teleological Significance of Beta Adrenergic Receptors in Muscle Blood Vessels*)

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ABSTRACT

Teleological significance of the pressence of beta adrenergic receptors in blood vessels of skeletal muscle seems to be in redistributing blood flow from viscera to skeletal muscle when muscular activity is required or anticipated. Adrenaline secreted from the adrenal medulla in such occasions constricts blood vessels in viscera as its alpha effect and dilates blood vessels in muscle as its beta effect. The latter effect is considered to be especially important in the rat which lacks cholinergic vasodilator fibers.

Beta receptor activity detected as vasodilation on administration of adrenaline is most marked in skeletal muscle, but its teleological significance is obscure[5]. At least in the rat the presence of such a vasodilator mechanism seems to be advantageous in increasing muscle blood flow when muscular activity is required or anticipated. In a previous study[9], we observed a conspicuous beta adrenergic vasodilatation in transposition response of the rat, induced by transposing the animal from its home cage to a new cage. In this responce in which the sympathoadrenal system is excited presumably triggered by the stress of change of habitat, cardiac output is increased and arterial pressure remains almost unchanged: total peripheral resistance is decreased. Beta adrenoceptor blockade with propranolol converts this isopressor response to a pressor one. The arterial pressure and total peripheral resistance are then both elevated on transposition of the rat.

In search for the vascular bed responsible for the decrease in total peripheral resistance in transposition response, changes in peripheral blood flow were observed using an electromagnetic flow probe chronically implanted at the terminal aorta, renal artery, superior mesenteric artery, and common carotid artery[8]. Of these four arteries, blood flow was increased in transposition response only in the terminal aorta supplying the hindquarters. Blood flow was markedly decreased in the superior mesenteric and renal arteries and was almost unchanged in the common carotid artery.

The increase in hindquarter flow in transposition response was greatly diminished after

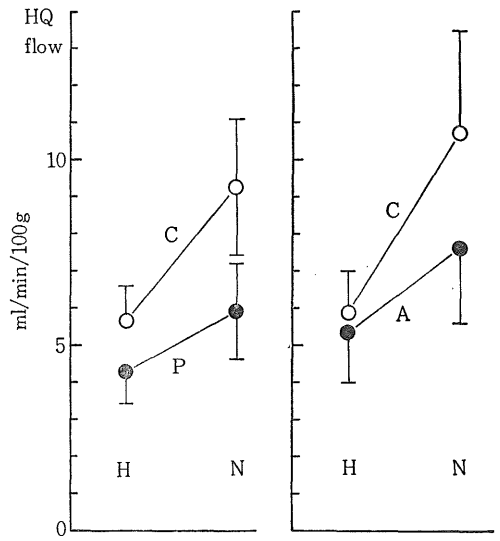

Fig. 1. Effect of propranolol (1 mg/kg, i. p., 30′ before) (left side) and adrenalectomy (2 days before) (right side) on the increase in hindquarter flow in transposition response induced by trancposing rats from their home cage to a new cage. H: home cage, N: new cage, C: control, P: after propranolol, A: after adrenalectomy. mean±SD. n=8 (propranolol), n=5 (adrenalectomy).

*) 入内島十郎：筋血管 β-レセプターの目的論的意義

beta adrenoceptor blockade with propranolol or after adrenalectomy. The effect of propranolol in 8 rats is summarized in the left side of Fig. 1. The hindquarter flow was increased in transposition response by 63.9±14.1% (mean±SD, n=8) before propranolol (open circles), while it was only increased by 38.2±21.0% 30 minutes after it (closed circles). However, the increase in hindquarter flow in transposition response was still significant after propranolol ($P<0.005$). The resting level of hindquarter flow was also significantly diminished by propranolol ($P<0.005$).

The summary data from 5 rats on the effect of adrenalectomy are presented in the right side of Fig. 1. By adrenalectomy also, the increase in hindquarter flow in the response was significantly diminished ($P<0.05$). Again, the diminished increase was still significant ($P<0.01$).

The foregoing findings indicate that a considerable portion of the increase in hindquarter flow and also cardiac output in transposition response is attributable to the beta effect of adrenaline released from the adrenal medulla. In the rat, as in most adult animals, the major part of hormones from the adrenal medulla is adrenaline[6,10].

The decrease in superior mesenteric flow in transposition response was also less after adrenalectomy than before. The summary data from 6 rats are presented in Fig. 2. The percent decrease of the flow in the response was −30.7±13.0% (mean±SD, n=6) (significant at $P<0.005$) before adrenalectomy and −16.1±10.6% after it ($P<0.025$). The difference between the two changes was significant at $P<0.025$. A similar abatement of the decrease in flow in transposition response by adrenalectomy was observed in the renal artery.

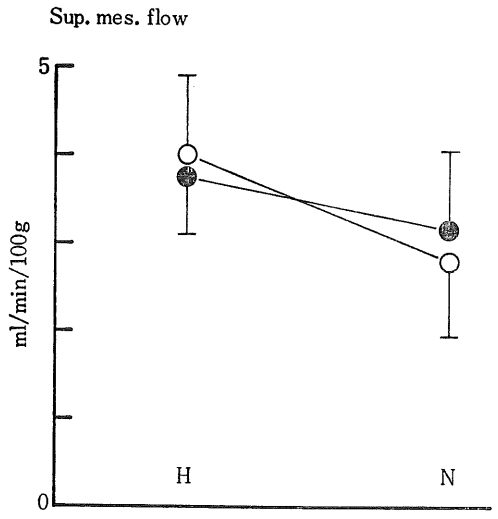

Fig. 2. Effect of adrenalectomy on the decrease in superior mesenteric flow in transposition responce. Open circles before adrenalectomy and filled circles after it. mean±SD. n=6.

Taken together, adrenaline relased from the adrenal medulla in transposition response dilates blood vessels in skeletal muscle by its beta effect and constricts those in viscera by its alpha effect. In this way adrenaline from the adrenal medulla plays an important part in shifting blood flow from viscera to muscle in transposition response. It seems that the teleological significance of the presence of abundant beta adrenergic receptors in the vascular bed of skeletal muscle is to increase the flow in response to adrenaline from the adrenal medulla in such occasions as to require or anticipate muscular activity. This mechanism must be especially important in the rat which lacks cholinergic sympathetic vasodilator fibers[1,7].

The present findings also explain why the major part of hormones from the adrenal medulla must be adrenaline and not noradrenaline. With a more marked beta effect together with a comparable alpha effect, adrenaline is considered to be a more suitable blood flow redistributor from viscera to muscle than noradrenaline. This function of adrenaline was first pointed out by Cannon[2,3] and then advocated by Folkow et al.[4] Our study has revealed that such a function really operates in conscious rats.

The decrease in the resting level of hindquarter flow and also cardiac output by propranolol suggests that muscular blood vessels are "tonically" dilated by a constant secretion of adrenaline from the adrenal medulla.

There seems to be little doubt that after adrenalectomy the remaining decrease in mesenteric flow in transposition response is effected by an excitation of regional sympathetic vasoconstrictor fibers. The most possible cause of the remaining increase in hindquarter flow in the response in adrenalectomized rats would be a specific inhibition of the tone of regional sympathetic vasoconstrictor fibers, reciprocal to

the excitation of those to viscera. Thus, it is considered that the blood flow redistribution in transposition response is effected by cooperation between adrenal adrenaline as a humoral blood flow redistributor and reciprocal, differentiated excitation and inhibition of regional sympathetic vasoconstrictor fibers.

REFERENCES

1. **Bolme, P., Novothy, J., Uvnäs, B. and Wright, P. G.** 1970. Species distribution of sympathetic cholinergic vasodilator nerves in skeletal muscle. Acta Physiol. Scand. **78** : 60-64.
2. **Cannon, W. B.** 1914. The emergency function of the adrenal medulla in pain and the major emotions. Am. J. Physiol. **33** : 356-372.
3. **Cannon, W. B. and Britton, S. W.** 1927. Studies on the conditions of activity in endocrine glands. XX. The influence of motion and emotion on medulliadrenal secretion. Am. J. Physiol. **79** : 433-465.
4. **Folkow, B., Frost, J. and Uvnäs, B.** 1948. Action of adrenaline, nor-adrenaline and some other sympathomimetic drugs on the muscular, cuntaneous and splanchnic vessels of the cat. Acta Physiol. Scand. **15** : 412-420.
5. **Green, H. D. and Kepchar, J. H.** 1959. Control of peripheral resistances in major systemic vascular beds. Physiol. Rev. **39** : 617-686.
6. **Green, R. D. and Miller, J. W.** 1966. Catecholamine concentrations: changes in plasma of rats during estrous cycle and pregnancy. Science **151** : 825-826.
7. **Iriuchijima, J.** 1980. Evidence against the presence of sympathetic vasodilator fibers in the rat. Ito, M. (ed.) Integrative Control Functions of the Brain. Vol. **2**, 239-240.
8. **Iriuchijima, J., Kawaue, Y. and Teranishi, Y.** 1982. Blood flow redistribution in the transposition response of the rat. Jpn. J. Physiol. **32** : 807-816.
9. **Iriuchijima, J., Teranishi, Y. and Eguchi, C.** 1980. Transposition response, a cardiovascular response to change of habitat in the rat. Jpn. J. Physiol. **30** : 887-896.
10. **Shepherd, D. M. and West, G. B.** 1951. Nor adrenaline and the suprarenal medulla. Brit. J. Pharmacol. **6** : 665-674.