Nutritive and non-nutritive blood flow and oxygen consumption in active rat skeletal muscle

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The objective of this study was to investigate the relationship between muscle metabolism and vascular distribution in the rat hindlimb. Clark *et al.*, (1995) categorised vasoconstrictors into two groups using a perfused sacrificed hindlimb model. All increase perfusion pressure, with Type A (low dose noradrenaline (NAd), vasopressin, angiotensin II) increasing oxygen uptake ($\dot{V}O_2$) redirecting blood into nutritive capillary beds associated with the muscle tissue) and Type B (serotonin (5-HT), high dose noradrenaline) decreasing hindlimb oxygen consumption, redirecting blood into non-nutritive capillary beds (associated connective tissue, adipose and septum). We used the in vivo autoperfused rat hindlimb with maintained vascular resistance to test the hypothesis that nutritive/ non-nutritive blood flow distribution can be observed in metabolically active (contracting) muscle and can be differentiated by vasodilators.

Male Wistar rats were anaesthetised with sodium pentobarbital (6mg/100g body weight i.p.). Polyethylene cannulae were filled with 0.9% heparinised saline containing 6% w/v dissolved dextran70. Mean systemic blood pressure was recorded from the left common carotid artery. The right femoral artery was cannulated to supply blood to the left femoral artery (perfused) passed through a pump for constant flow. Perfused hindlimb pressure was recorded via a side arm pressure transducer distal to the pump. Passive venous return occurred from the left femoral vein to the right external jugular vein. The left sciatic nerve was stimulated via a bipolar electrode and tension development recorded in the gastrocnemius muscle bundle. Vasoactive drugs (2 constrictor, 8 dilator) were prepared with saline and 0.01% ascorbic acid, and injected into the arterial loop. Blood was sampled from the venous and arterial loops and $\dot{V}O_2$ determined using the Fick equation.

During basal conditions, NAd (100nM – 256μM) increased mean perfusion pressure by up to 260 ± 34% ($P < 0.001$, n = 6, mean ± SEM) and 5-HT (12.5μM – 100μM) by up to 225 ± 30% ($P < 0.005$, n = 6). The $\dot{V}O_2$ did not change during NAd infusion but decreased by up to 67 ± 7% during 5-HT infusion ($P < 0.005$). Mean perfusion pressure was decreased during the infusion of isoprenaline by 33 ± 2% ($P < 0.001$, n = 6) and histamine by 25 ± 2% ($P = 0.05$, n = 6) whilst $\dot{V}O_2$ did not change.

During muscle contraction, NAd increased mean hindlimb pressure by 96 ± 3% ($P < 0.001$) and 5-HT increased by 112 ± 12% ($P < 0.001$). $\dot{V}O_2$ by 46 ± 10% ($P < 0.05$). Isoprenaline and histamine decreased mean perfusion pressure by 24 ± 3%($P < 0.005$) and 9 ± 3% respectively ($P < 0.01$). Both vasodilators increased $\dot{V}O_2$, isoprenaline by 175 ± 40% ($P < 0.01$) and histamine by 96 ± 40% ($P < 0.05$).

These results show that the vasoconstrictors NAd and 5-HT have opposing effects on $\dot{V}O_2$ during both basal and twitch conditions. However we were unable to find a vasodilator that could decrease $\dot{V}O_2$ in a similar fashion to 5-HT. The reduced effect of 5-HT on $\dot{V}O_2$ during twitch maybe due to local effects of the twitch (such as vasoactive metabolites) on oxygen demand, hence overriding the vasoconstriction of the nutritive pathway.

Clark, M.G., Colquhoun, E.Q., Rattigan, S., Dora, K.A., Eldershaw, T.P.D., Hall, J.L. & Ye, J. (1995) *American Journal of Physiology: Endocrinology and Metabolism*, 31, E797-E812.