The influence of cardiac output variability on cerebral blood flow velocity variability during exercise in humans.

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Introduction

Cerebral autoregulation (CA) is important in the regulation of cerebral blood flow (Ogho et al. 2005a, b). In addition, the middle cerebral artery mean blood flow velocity (MCA Vmean) is influenced by systemic blood pressure regulation (Ide & Secher, 2000). The increase in MCA Vmean reported with exercise appears to depend on the ability to increase cardiac output (Q), as demonstrated in response to β-1 blockade and in patients with cardiac insufficiency or atrial fibrillation (Ide & Secher, 2000). Arterial baroreflex (ABR) control of arterial blood pressure (ABP) operates via two separate reflex arcs, which for the carotid baroreflex (CBR) are defined as the carotid-cardiac or carotid-vasomotor arm. During exercise, the carotid-vasomotor arm of the reflex predominates in the regulation of ABP (Ogho et al. 2003). However, the cardiac ABR responses at the operating point (OP) decrease from rest to maximal exercise (Ogho et al., 2005c). Therefore, if the contribution of the variability in Q to the beat-to-beat MCA Vmean remains stable during exercise, the reduction of cardiac ABR sensitivity at the OP would result in less control of the beat-to-beat MCA Vmean. This study evaluated the influence of Q variability on beat-to-beat MCA Vmean during exercise with and without cardiac β-1 adrenergic blockade.

Methods

Eight men (22±1yrs; means±SE) performed 15 min bouts of moderate (EX130; 105±11W) and heavy (EX160; 162±8W) intensity cycling before and after cardio-selective β-1 adrenergic blockade (0.15 mg/kg metoprolol). The beat-to-beat changes in Q (%), determined by Modelflow technology, heart rate (HR), ABP and MCA Vmean were also obtained. Transfer function gain, phase shift and coherence between changes in Q and MCA Vmean and between mean arterial pressure (MAP) and MCA Vmean were calculated. In addition, transfer function gain between MAP and HR was calculated to evaluate dynamic cardiac ABR gain.

Results

At rest, metoprolol did not significantly affect blood gas variables or HR, stroke volume (SV) and Q. However, the MAP and MCA Vmean decreased by 7.6% and 13.4%, respectively (P<0.05). Without metoprolol, HR, MAP, Q and blood lactate concentration (La) gradually increased from rest to EX160 (P<0.05). The MCA Vmean and PaCO2 increased by 25% and 9.6%, respectively (P<0.05) from rest to EX130, but the MCA Vmean decreased by 11% and PaCO2 by 5% from EX130 to EX160. After the administration of metoprolol during exercise, all cardiovascular variables increased during exercise, however, the increases in HR, MAP, Q, MCA Vmean and La were lower than control values (P<0.05). The SV and PaCO2 were not influenced significantly by cardio-selective β-1 blockade. Both exercise and metoprolol decreased the Low frequency (LF) transfer function gain between %Q and MCA Vmean (P<0.05). However, during EX130 and EX160 there was no significant difference in the LF transfer function gain with and without after β-1 blockade. During exercise, the transfer function gain between MAP and MCA Vmean remained stable and were not different from the resting values with and without metoprolol (P>0.05). The transfer function gain between HR and MAP, an index of cardiac ABR responses at the OP, decreased from rest to EX160 (P<0.05). In addition, the exercise-induced reduction in cardiac ABR gain was significantly related to a decrease in the transfer function gain between Q and MCA Vmean from rest to EX160 (R=0.942, P<0.05).

Discussion/Conclusion

An important finding of the present investigation was that the contribution of Q variability (cardiac-arterial baroreflex) to MCA Vmean variability decreased from rest to heavy exercise. Furthermore, a reduced steady-state Q or MCA Vmean induced by β-1 blockade did not alter the influence of Q variability on MCA Vmean variability during exercise. However, exercise and the administration of β-1 blockade did not significantly affect the transfer function gain between beat-to-beat MAP and MCA Vmean. These data suggest that during exercise the control of systemic blood pressure (i.e., arterial baroreflex control of vasomotion) becomes more important than the cardiac ABR in the beat-to-beat regulation of MCA Vmean, even though steady-state Q determined MCA Vmean.

References