Cerebral blood flow in high-altitude native children

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Résumé

Introduction

Since it has virtually no local reserve, the brain is known to be utterly sensitive to the lack

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of oxygen as experienced during hypoxia. Therefore, sufficient perfusion must be ensured to maintain cerebral oxygen delivery (CDO2) in spite of the reduced O2 partial pressure (Brugniaux et al., 2007). While cerebral blood flow (CBF) regulation has already been studied with adult high-altitude natives of various ethnicities, including Andeans, presenting with lower CBF (Bailey et al., 2019), little is known about resting patterns of CBF in children born and bred at altitude. Therefore, the aim of this study was to quantify CBF in children of Andean descent living at 5,100 m and compare them to children living at lower altitudes and to lowlander children at sea-level.

Methods

A total of 160 children (80 boys) aged 8–12 years, living at sea level (Lima, n = 40, 28 boys), 3,400m (Cusco, n=38, 13 boys), 3,800 m (Juliaca, n =40, 17 boys) or 5,100 m (La Rinconada, n = 42, 22 boys) were recruited in this study. All were of Aymaran or Quechua descent. High-altitude native children were all born above 3,000m and raised at their respective altitudes of residence and testing.

After at least 10min of supine rest, volumetric measures of CBF within the common carotid artery (CCA), internal carotid artery (ICA), and vertebral artery (VA) was assessed using a 10-MHz multi-frequency linear array duplex ultrasound (e-Cube i7, Alpinion, Republic of Korea) according to published technical recommendations (Thomas et al., 2015). Vessel diameter was measured using B-mode imaging, whereas pulse-wave mode was used to simultaneously measure peak envelope blood velocity. Global CBF (gCBF) was estimated as twice the sum of the unilateral ICA and VA measurements, which were calculated using peak velocity and the cross-sectional area of the respective vessels. Associated measurements included hemoglobin ((Hb)) concentration, hematocrit (Hct), plasma volume (PV) and blood viscosity. One-way ANOVAs were used to detect differences between groups with Tukey post hoc comparisons when applicable (Jamovi, v.2.5.7.0).

Results

There were no differences regarding the age and anthropometric characteristics, between the 4 groups, but as expected, (Hb) increased with altitude. There was an overall effect of altitude on gCBF (P=0.032), but post hoc analyses did not reveal any further differences. However, there were regional differences, since blood flow in the VA was significantly lower in Juliaca than in the other 3 altitudes, while now alteration was observed in the ICA.

Discussion

Maintained gCBF at the extreme altitude of La Rinconada, may seem counterintuitive, however, this is accompanied by an elevation in Hb and hence in oxygen content, contributing to defend CDO2 and consequently, reducing the need to increase CBF. Nevertheless, higher CBF was associated with increased HR and PV, both probably stimulating the endothelium to relax via shear-mediated mechanisms. Conversely, an increase in Hct and/or viscosity, that were both observed herein, have been suggested to be associated with lower gCBF, which we are confirming here. Taken together, these opposing mechanisms probably explain the relatively stable gCBF.

Posterior brain circulation being involved in the development of cognition (and overall homeostasis), the lower VA blood flow observed in Juliaca, and the global lack of response to altitude is intriguing and warrants further research.

Conclusions

Despite altitude-induced hypoxemia, brain perfusion appears well-preserved. Nevertheless, regional differences seem to exist. The potential consequences of these differences on the (cognitive) development of these children remain to be elucidated.

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