CRITICAL CARE

LETTER

Tissue hypoxia during acute hemorrhage

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See related commentary by Calzia *et al.*, http://ccforum.com/content/16/6/183

Calzia and colleagues argue [1] that tissue hypoxia in a rat model of hemorrhage that led to an oxygen deficit of 120 ml/kg with hyperlactacidemia [2] may be modest, and may not affect hydrogen sulfide oxidation since '... the arterial oxygen partial pressure was still normal ...' [1]. This contention requires clarification.

A relative hyperventilation is the rule in most experimental models of hemorrhage [2,3], since the reduction in oxygen uptake/consumption ($\dot{V}O_2$) is always larger than that in alveolar ventilation ($\dot{V}A$). Alveolar oxygen partial pressure therefore increases during hemorrhage, as it is the ratio between $\dot{V}O_2$ and $\dot{V}A$ (and not the absolute level of $\dot{V}A$) that dictates the partial pressure of oxygen in the alveolar gas (PAO_2):

$$PAO_2 = PIO_2 - k\dot{V}O_2 / \dot{V}A$$

This tells us very little about the level of tissue hypoxia.

In all of the models used to study an acute hemorrhage, the baseline oxygen delivery rate ($DO_2 = \dot{Q}C_aO_2$) is three to four times higher than $\dot{V}O_2$, despite a large discrepancy in $\dot{V}O_2$ per kilogram between a 500 g rat, a 20 kg pig or a human being: cardiac output, DO_2 and $\dot{V}O_2$ do share a similar allometric function with body weight, so that the blood oxygen content is the same in most species. $\dot{Q}$ drops dramatically during hemorrhage, reducing DO_2. The level of DO_2 decreases up to 10 times while $\dot{V}O_2$ drops by four times regardless of the size of animal chosen [3,4] so that both DO_2 and $\dot{V}O_2$ reach one-third of the baseline metabolic rate at the end of a severe hemorrhage! This should certainly lead to one of the most severe forms of tissue hypoxia – with normal arterial blood oxygen partial pressure – unless a decrease in oxygen demand contributes significantly to the reduction in $\dot{V}O_2$ induced by the decline in DO_2. Indeed, although the relationship between DO_2 and $\dot{V}O_2$ is similar across species, the meaning of a reduction in $\dot{V}O_2$ can greatly differ among animal models according to their ability to decrease the oxygen demand [3,5] – a phenomenon present during hemorrhage in small mammals [3]. It is eventually this ability to modify oxygen demand during a hemorrhage, in keeping with DO_2, which controls the level of tissue hypoxia, and not the absolute levels of PaO_2, DO_2 or $\dot{V}O_2$.

Abbreviations

C_aO_2, concentration (content) of oxygen in the arterial gas; DO_2, rate of oxygen delivery ($\dot{Q}C_aO_2$); PAO_2, partial pressure of oxygen in the alveolar gas; PIO_2, partial pressure of oxygen in the inspired gas; $\dot{Q}$, cardiac output; $\dot{V}A$, alveolar ventilation; $\dot{V}O_2$, oxygen uptake/consumption.

Competing interests

The author declares that he has no competing interests.

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