

Relationship between retinal blood flow and arterial oxygen

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Abstract

Retinal blood flow (RBF) increases in response to a reduction in oxygen (hypoxia) but decreases in response to increased oxygen (hyperoxia). However, the relationship between blood flow and the arterial partial pressure of oxygen has not been quantified and modelled in the retina, particularly in the vascular reserve and resting tonus of the vessels. The present study aimed to determine the limitations of the retinal vasculature by modelling the relationship between RBF and oxygen. Retinal vascular responses were measured in 13 subjects for eight different blood gas conditions, with the end-tidal partial pressure of oxygen (P_{ETC} O₂) ranging from 40–500mmHg. Retinal vascular response measurements were repeated twice: using the Canon laser blood flowmeter (Canon Inc., Tokyo, Japan) during the first visit and using Doppler spectral domain optical coherence tomography during the second visit. We determined that the relationship between RBF and PaO₂ can be modelled as a combination of hyperbolic and linear functions. We concluded that RBF compensated for decreases in arterial oxygen content for all stages of hypoxia used in the present study but can no longer compensate below a P_{ETC} O₂ of 32–37mmHg. These vessels have a great vascular range of adjustment. Increasing diameter (8.5% arteriolar and 21% total venous area) with hypoxia (40mmHg P_{ETC} O₂; P<0.001) and decreasing diameter (6.9% arteriolar and 23% total venous area) with hyperoxia (500mmHg P_{ETC} O₂; P<0.001) to the same extent. This indicates that the resting tonus is near the mid-point of the adjustment ranges at resting PaO₂ where sensitivity is maximum.

Keywords

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Abstract

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Key points: Vascular reactivity, the response of the vessels to a vasoactive stimulus such as hypoxia and hyperoxia, can be used to assess the vascular range of adjustment in which the vessels are able to compensate for changes in PO₂. Previous studies in the retina have not accurately quantified retinal vascular responses and precisely targeted multiple PaO₂ stimuli at the same time as controlling the level of carbon dioxide, thus precluding them from modelling the relationship between retinal blood flow and oxygen. The present study modelled the relationship between retinal blood flow and PaO₂, showing them to be a combined linear and hyperbolic function. This model demonstrates that the resting tonus of the vessels is at the mid-point and that they have great vascular range of adjustment, compensating for decreases in oxygen above a P_{ETC} O₂ of 32–37 mmHg but being limited below this threshold. Retinal blood flow (RBF) increases in response to a reduction in oxygen (hypoxia) but decreases in response to increased oxygen (hyperoxia). However, the relationship between blood flow and the arterial partial pressure of oxygen has not been quantified and modelled in the retina, particularly in the vascular reserve and resting tonus of the vessels. The present study aimed to determine the limitations of the retinal vasculature by modelling the relationship between RBF and oxygen. Retinal vascular responses were measured in 13 subjects for eight different blood gas conditions, with the end-tidal partial pressure of oxygen (P_{ETC} O₂) ranging from 40–500 mmHg. Retinal vascular response measurements were repeated twice; using the Canon laser blood flowmeter (Canon Inc., Tokyo, Japan) during the first visit and using Doppler spectral domain optical coherence tomography during the second visit. We determined that the relationship between RBF and PaO₂ can be modelled as a combination of hyperbolic and linear functions. We concluded that RBF compensated for decreases in arterial oxygen content for all stages of hypoxia used in the present study but can no longer compensate below a P_{ETC} O₂ of 32–37 mmHg. These vessels have a great vascular range of adjustment, increasing diameter (8.5% arteriolar and 21% total venous area) with hypoxia (40 mmHg P_{ETC} O₂; P < 0.001) and decreasing diameter (6.9% arteriolar and 23% total venous area) with hyperoxia (500 mmHg P_{ETC} O₂; P < 0.001) to the same extent. This indicates that the resting tonus is near the mid-point of the adjustment ranges at resting PaO₂ where sensitivity is maximum. © 2016 The Physiological Society.

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