Regulation of ocular oxygen perfusion: principles and working mechanisms

Vascular factors have differing amounts of influence on ocular perfusion. Understanding these effects may allow new treatment approaches to a variety of diseases.

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Vascular and hypoxic factors are increasingly considered in discussing the development of several ocular diseases, including acute and chronic glaucoma, retinal vascular diseases and ischemic optic neuropathy. Nocturnal arterial hypotonia, vasospastic effects, arteriolosclerosis and capillary atrophy are important items in this concept.

This article reviews factors such as perfusion pressure, intraocular pressure, vascular diameter and length, hemoglobin, blood viscosity and oxygen saturation, enabling us to measure the importance of these factors concerning ocular perfusion. This multifactorial model reveals items for complex therapy opportunities.

A cascade of local processes, for instance the production of free radicals, causes apoptosis of retinal ganglion cells. This hypoxic-nutritive lack can be determined by a modification of the Hagen-Poseuille formula defining the oxygen time volume as a specific dimension of ocular oxygen perfusion. (See the accompanying figure.)

Regulation of parameters

The adaptation of local perfusion is determined by the regulation of different parameters:

Hematocrit: The hematocrit mainly determines blood viscosity; other factors such as corpuscular elements or plasma proteins (M. Waldenstrom) can be neglected. Standard hematocrit varies between 45.7% and 47.0% in men and 38.2% and 43.0% in women. An increase of 10% causes a reduction in oxygen perfusion of 8%. Variation of oxygen perfusion inside the standard hematocrit range can be up to 11.8%.

Consequences of therapy include hemodilution, reduction of corpuscular elements and plasmaproteins.

Oxygen saturation: Standard oxygen saturation varies between 95% and 97%. A decrease of 10% lowers oxygen perfusion 10%.

Therapy consequences include controlled increase of arterial oxygen saturation.

Hemoglobin: Standard hemoglobin varies between 14 g/dl and 18 g/dl in men and 12 g/dl and 16 g/dl in women. A 10% reduction causes a 10% reduction of oxygen perfusion. Variation inside the standard range can cause an oxygen deficit of approximately 22.2%.

Therapy consequences include treatment of anemia and avoidance of volume deficit.

Ocular perfusion pressure: Standard ocular perfusion pressure varies between 75 mm Hg and 100 mm Hg. A 10% decrease causes an oxygen deficit of 10%. Variations inside the standard range can reduce oxygen perfusion up to 25.4%.

For example, a decrease of systemic blood pressure from 120/80 mm Hg to 70/40 mm Hg reduces – if the intraocular pressure is quite normal – oxygen perfusion 59%. Assuming the intraocular pressure to be 50 mm Hg, there

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