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Retinal Vessel Oxygen Saturation in Patients With Diabetic Retinopathy

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Purpose

The purpose of this study was to measure oxygen saturation in retinal blood vessels in patients with diabetic retinopathy (DR).

Methods

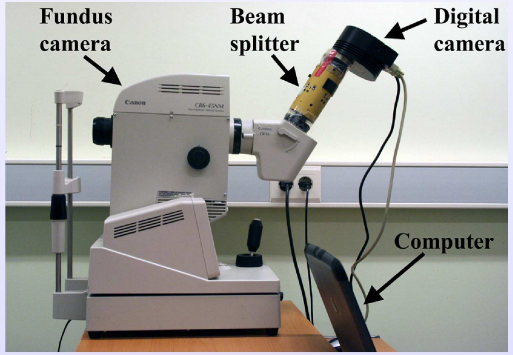

Figure 1. The retinal oximeter.

Our automatic retinal oximeter [1] is based on a fundus camera. It yields fundus images with four wavelengths of light simultaneously. Two wavelengths, 605nm and 586nm, are used for calculation of oxygen saturation. Specialized software automatically selects measurement points on the oximetry fundus images and estimates the oxygen saturation in retinal vessels.

Oximetry was performed in one first or second degree temporal retinal vessel in 31 healthy individual and 28 patients with diabetic retinopathy, see table 1.

One-way ANOVA and Dunnett's post test were used for statistical analysis.

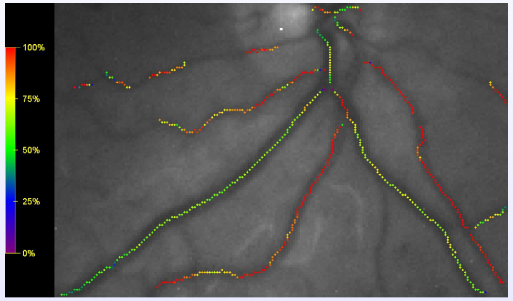

Figure 2. A Pseudocolor map of a fundus, showing oxygen saturation in retinal vessels. The image is from an eye with proliferative DR.

Table 1. The groups studied.

Healthy volunteers, n=31	
Age	32±15 years (mean±SD)
Gender	19 males, 12 females
Background DR, no macular edema, n=6	
Age	57±16 years (mean±SD)
Gender	3 males, 3 females
No. with type of diabetes	2 type I, 4 type II
Duration with diabetes	17±11 years (mean±SD)
Diabetic macular edema, no treatment, n=7	
Age	60±15 years (mean±SD)
Gender	5 males, 2 females
No. with type of diabetes	2 type I, 5 type II
Duration with diabetes	19±9 years (mean±SD)
Pre-proliferative / proliferative DR, no treatment, n=7	
Age	42±14 years (mean±SD)
Gender	6 males, 1 female
No. with type of diabetes	6 type I, 1 type II
Duration with diabetes	20±5 years (mean±SD)
Proliferative DR, stable after treatment, n=8	
Age	44±17 years (mean±SD)
Gender	6 males, 2 females
No. with type of diabetes	5 type I, 3 type II
Duration with diabetes	21±5 years (mean±SD)

Results

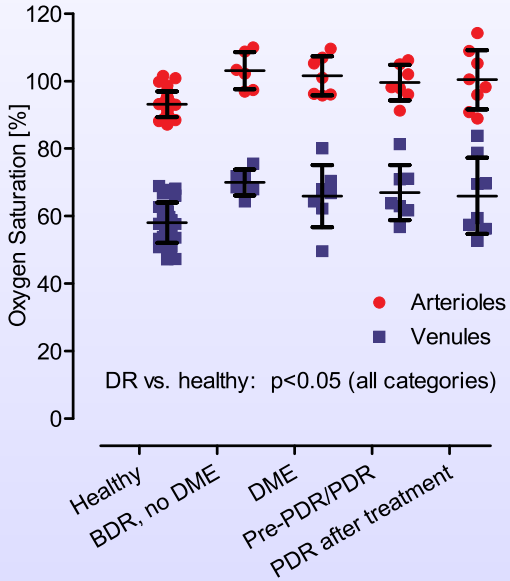

Figure 3. Oxygen saturation (%) in first and second degree arterioles and venules. Each point denotes a measurement in one temporal vessel. Only one arteriole and one venule were measured in each eye. Bars denote means and SDs.

Table 2. Oxygen saturation (%). Same measurements as shown in fig. 3. Mean±SD.

	Arterioles	Venules
Healthy volunteers, n=31	93±4%	58±6%
Background DR, no macular edema, n=6	103±6%	70±4%
Diabetic macular edema, no treatment, n=7	102±6%	66±9%
Pre-proliferative / proliferative DR, no treatment, n=7	100±5%	67±8%
Proliferative DR, stable after treatment, n=8	100±9%	66±11%

For statistical significance, see fig. 3. Arteriovenous difference was similar in all groups.

Discussion

Although better age and gender matching is needed, our results indicate that both retinal arterial and venous oxygen saturation is greater in patients with diabetic retinopathy, than in healthy individuals. This is despite prior evidence for retinal tissue hypoxia in diabetic retinopathy [see for example ref. 2]. There are several possible explanations for our findings (not mutually exclusive):

- Total retinal blood flow may be increased (relative to demand).
- Oxygen consumption may have decreased due to degeneration of tissue.
- Treatment may increase saturation in the treated group.
- Glycosylated hemoglobin has greater affinity for oxygen (2,3 DPG decreases affinity).
- Distribution of blood and oxygen to tissue may be impaired.
  - Capillary shunts and dropout (figure 4).
  - Thicker vessel walls and less diffusion.

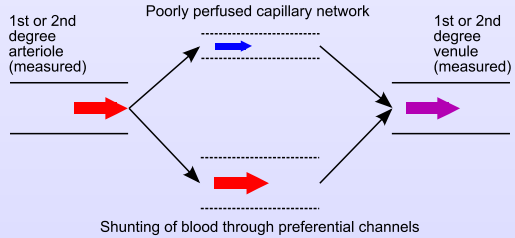

Figure 4. The measured retinal venules in the diabetic patients drain both poorly perfused parts of the capillary network and preferential channels. The poorly perfused tissue will be hypoxic while the shunting will raise the measured saturation in venules.

Conclusions

Oxygen saturation in retinal arterioles and venules is greater in diabetic patients than in healthy individuals. Possible explanations include increased total retinal blood flow, decreased oxygen consumption and poor distribution of blood and oxygen.

1. Hardarson, S.H. et al. (2006). "Automatic retinal oximetry." Invest Ophthalmol Vis Sci 47(11): 5011-6.
2. Linsenmeier, R.A. et al. (1998). "Retinal hypoxia in long-term diabetic cats." Invest Ophthalmol Vis Sci 39(9): 1647-57.

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