European Journal of Ophthalmology / Vol. 17 no. 5, 2007 / pp. 755-759

Ocular surface temperature in central retinal vein occlusion: Preliminary data

A. SODI[1], B. GIAMBENE[1], G. FALASCHI[2], R. CAPUTO[3], B. INNOCENTI[2], A. CORVI[2], U. MENCHINI[1]

[1]Eye Clinic
[2]Department of Mechanics and Industrial Technology, University of Firenze, Firenze
[3]Pediatric Ophthalmology Unit, A. Meyer Children Hospital, Firenze - Italy

PURPOSE. *To compare ocular surface temperature (OST) measures in patients with central retinal vein occlusion (CRVO) and controls.*
METHODS. *Thirty-six patients with unilateral CRVO and 54 healthy volunteers were included in the study. OST was evaluated by infrared thermography.*
RESULTS. *In CRVO eyes and in fellow, nonaffected eyes, OST values were lower than in controls ($p<0.05$). Ischemic CRVO eyes showed lower temperatures than nonischemic ones.*
CONCLUSIONS. *Infrared thermography may be helpful in the management of patients with CRVO. (Eur J Ophthalmol 2007; 17: 755-9)*

KEY WORDS. *Central retinal vein occlusion, Infrared thermography, Ocular surface temperature*

Accepted: March 6, 2007

INTRODUCTION

Ocular surface temperature (OST) is determined by extraocular factors, such as body and environmental temperature, and ocular factors, such as the features of tear film layer and ocular blood flow (1-4).
Infrared thermography allows evaluation of the features of the local blood flow, by measuring the radiated heat from the body surface. It is widely used to study abnormalities in blood flow in rheumatic diseases, dentistry, oncology, and vascular disorders (5-9).
This noninvasive technique also allows for reliable eye temperature measurements. Normal ocular thermographic profiles are reported in a recent review by Purslow and Wolffsohn (10).
Previous studies have demonstrated OST changes in dry-eye syndromes, anterior uveitis, retinoblastoma, and during phacoemulsification and photorefractive treatments (11-17).
Ocular thermography seems to be particularly suitable to study ocular hemodynamics. The results of some investigations indicate a possible correlation between OST and ocular blood flow (18-22). No information about ocular thermographic patterns in retinal occlusive diseases is available.
Retinal vein occlusion (RVO) is frequently associated with cardiovascular diseases (stroke, myocardial infarction, heart valvulopathies) and shares with them the same risk factors (smoking, diabetes, arterial hypertension, dyslipidemia, coagulation disorders, and blood hyperviscosity) (23-34). In some cases RVO may occur in the absence of any apparent systemic risk factor, suggesting that local vascular abnormalities may play a role in the pathogenesis of this disease. Therefore, it is possible to speculate that RVO is a multifactorial disorder determined by a combination of systemic and local pathogenetic agents. The convergence of the different factors may be unique for each patient and the attempt to explain all the types of retinal vein occlusion with a common pathogenetic mechanism may be misleading.
The individual pathogenetic background determining the onset of the disease probably also influences the great variability in its natural history, with cases rapidly progressing towards severe retinal neovascularization and

 1120-6721/755-05$15.00/0

neovascular glaucoma, aside with patients with a more favorable prognosis. Several criteria have been proposed to distinguish more or less progressive forms of RVO and the most used in clinical practice is the extent of retinal ischemia at the fluorangiographic examination (35-40). Retinal angiographic nonperfusion is only one of the factors, even if probably the most important one, determining the evolution of the disease. A better understanding of the other factors (like ocular hemodynamics) might be clinically useful to monitor its progression and to plan more effective treatments. Considering the possible relationship between ocular blood flow and OST, ocular thermography may be suitable to evaluate ocular hemodynamics in patients with RVO.

The present study aimed at estimating if the ocular thermographic profiles obtained by means of infrared thermography in patients with central retinal vein occlusion (CRVO) might be useful in the management of this disease.

METHODS

Thirty-six patients with unilateral CRVO were included in the study. Fifteen were men and 21 women; their mean age was 65.6±8.2 years. Mean best-corrected visual acuity (BCVA), measured by Snellen chart, was 2.1±0.7 in the affected eye and 8.9±0.8 in the fellow eye. Mean intraocular pressure values, measured by Goldmann applanation tonometry, were 15.7±2.6 mmHg in the affected eye and 16.3±2.1 mmHg in the nonaffected eye, without medication. According to the CRVO Study classification, nine patients showed an ischemic form of RVO (that is, at the angiographic examination performed 1 month after the onset of the disease, the extension of vascular nonperfusion was larger than 10 times the optic disc area), while 27 had a perfused form of CRVO (39). Thermographic examination was performed in both eyes within 1 month from the onset of the disease.

The control group consisted of 54 age- and sex-matched healthy volunteers. Twenty-seven were men, 27 were women; their mean age was 64.7±7.3 years. The mean value of BCVA was 8.8±0.9 in right eyes and 9.1±0.7 in left eyes. IOP measurements showed a mean value of 15.2±1.9 mmHg in right eyes and 14.8±1.7 mmHg in left eyes. Thermographic examinations were performed in both eyes, but only one eye, randomly chosen, was considered for statistical analysis.

Exclusion criteria for both groups were refractive errors higher than 3 spherical diopters and 1.5 cylinder diopters, tear film abnormalities, body temperature lower than 36.4 or higher than 36.9 °C, ocular pathologies, and cardiovascular diseases. Except for some CRVO patients (16 were assuming aspirin 100 mg/day, 4 ticlopidine 250 mg/day), all the considered subjects were not receiving any systemic or topical medication.

Written informed consent was obtained by every subject and the tenets of the Declaration of Helsinki were observed.

OST measurements were performed by an infrared detector (Agema Thermovision® 800 LWB, AGEMA Infrared Systems 1991 AB, Donderyd, Sweden) in a room whose environmental microclimate was kept constant, with a temperature of 25 °C and a relative humidity of 55%.

The thermocamera was placed in front of the subject at a distance of about 30 cm, after a 20-min period of adaptation within the room. The patient was requested to keep both eyes closed and to open them just at the start of the registration, fixing the center of the camera. A 15-second film showing the patient's open eye's foreground was recorded; the patient was asked to keep both eyes opened for the duration of the test. In case of blinking, the registration was repeated from the beginning. Measurements were taken during the entire 15 seconds and data were recorded every second, but for the present investigation we considered only the first photogram of the film.

The temperature of five anatomic points equally spaced out, across a line running horizontally through the center of the cornea and connecting medial and lateral canthi, was recorded immediately after the eye opening.

Statistical analyses were carried out using the Student t-test for paired and unpaired samples. A p value lower than 0.05 was considered statistically significant.

RESULTS

All the examined eyes showed a thermographic profile characterized by a higher temperature at the extremities (points 1 and 5), and a lower temperature at the center of the cornea (point 3), in agreement with previous reports of eye surface thermographic patterns.

In CRVO eyes OST values were lower than in controls at all the considered points ($p<0.05$). The nonaffected eyes of CRVO patients revealed a similar trend, when compared with controls, but the difference was statistically

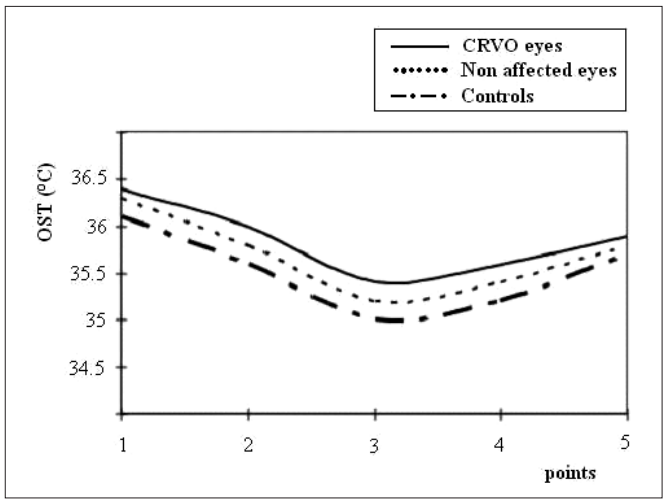

Fig. 1 - *Ocular surface temperature in CRVO patients and controls. OST = Ocular surface temperature. CRVO = Central retinal vein occlusion.*

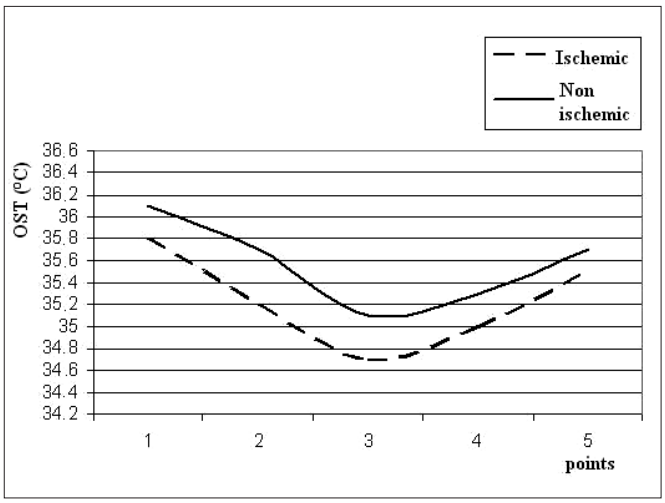

Fig. 2 - *Ocular surface temperature in ischemic and non ischemic eyes. OST = Ocular surface temperature.*

significant only at point 3 ($p<0.05$). Within the CRVO group, the affected eyes showed, in comparison with the nonaffected ones, lower OST measures at all five points, but the statistical significance was achieved only at point 3 ($p<0.05$). An overall view of the OST values in the three different groups of eyes is shown in Table I and Figure 1.
The comparison of ischemic and nonischemic CRVO eyes showed lower temperatures in the ischemic ones, but a statistical analysis was not performed because of the small sample size (Tab. II) (Fig. 2).

TABLE I - OCULAR SURFACE TEMPERATURE MEASURES (Mean ± SD) IN CRVO PATIENTS AND CONTROLS

Points	CRVO eyes	Nonaffected eyes	Controls
1	36.1±0.48	36.3±0.37	36.4±0.47
2	35.6±0.53	35.8±0.42	36.0±0.54
3	35.0±0.60	35.2±0.57	35.4±0.57
4	35.2±0.52	35.4±0.49	35.6±0.56
5	35.7±0.51	35.8±0.55	35.9±0.53

CRVO = Central retinal vein occlusion

DISCUSSION

Previous investigations showed a possible relationship between OST and ocular blood flow. In cynomolgus monkeys, an increase of intraocular pressure was found to be associated with a decrease of ocular perfusion pressure and ocular temperature (19). In healthy human subjects, a correlation between the corneal surface temperature and some retrobulbar blood flow parameters of the ophthalmic artery has been described (22). Ocular temperature was also related to finger temperature, suggesting a parallelism in eye and hand blood supply (20). In case of a reduction of ocular blood supply, as in severe carotid artery stenosis, the eye on the affected side appeared to be cooler (18-21). On the contrary, an increase in OST was found in eyes with conjunctivitis or anterior uveitis, where an increase in local blood flow is present (10-14).

TABLE II - OCULAR SURFACE TEMPERATURE MEASURES (Mean ± SD) IN ISCHEMIC AND NONISCHEMIC EYES

Points	Ischemic eyes	Nonischemic eyes
1	35.8±0.65	36.1±0.38
2	35.2±0.61	35.7±0.44
3	34.7±0.66	35.3±0.50
4	35.0±0.56	35.3±0.49
5	35.5±0.62	35.7±0.50

In the present study, the thermographic analyses show that OST significantly differs among CRVO eyes, nonaffected eyes of patients with CRVO, and controls. On average, the temperatures of the CRVO eyes were lower than

the corresponding values of the control eyes for all the considered locations; the nonaffected eyes showed intermediate values between CRVO eyes and controls. In CRVO eyes, the evidence of OST measures lower than in controls is likely to be explained by the local blood stasis. In the fellow, nonaffected eyes, this finding could indicate a more general impairment of blood flow. Previous investigations performed by means of color Doppler imaging have demonstrated a reduction of blood velocities and an increase of resistivity index of the retrobulbar vessels in CRVO eyes and in the fellow, nonaffected eyes (41-43). Our thermographic data seem to support the hypothesis that ocular hemodynamics could influence OST (22). The impairment of OST values also in the nonaffected eyes of CRVO patients might suggest the presence of systemic vascular risk factors which may significantly contribute to the pathogenesis of CRVO. This finding supports the clinical interest of an exhaustive assessment of vascular risk factors, like arterial hypertension, atherosclerosis, hyperlipidemia, thrombophilia, and blood hyperviscosity, to be performed in all patients with retinal vein occlusion.

Even if a statistical analysis was not possible because of the small sample size, in our series lower temperature measures in the ischemic CRVO eyes, in comparison with the nonischemic ones, were reported, as well as the possibilities of thermographic technology to evaluate blood flow alterations in ocular vascular diseases.

Ocular infrared thermography seems to be suitable to detect relevant thermographic differences between CRVO eyes, fellow, nonaffected eyes, and controls. Further investigations are needed to clarify the possible relationship between angiographic retinal ischemia and OST measures and therefore determine a possible prognostic value of ocular thermography in CRVO.

Moreover, this imaging method might provide clinical information helpful to better understand the physiopathology of other pathologic conditions affecting ocular hemodynamics, such as diabetic retinopathy and glaucoma.

The authors have no proprietary interest.

Reprint requests to:
Barbara Giambene, MD
Eye Clinic
Department of Oto-Neuro-Ophthalmological Surgical Sciences
Viale Morgagni, 85
50139 Florence, Italy
barbaragiambene@virgilio.it

REFERENCES

1. Mapstone R. Determinants of corneal temperature. Br J Ophthalmol 1968; 52: 729-41.
2. Mapstone R. Ocular thermography. Br J Ophthalmol 1970; 54: 751-4.
3. Freeman RD, Fatt I. Environment influences on ocular temperature. Invest Ophthalmol 1973; 12: 596-602.
4. Craig JP, Singh I, Tomlinson A, Morgan PB, Efron N. The role of tear physiology in ocular surface temperature. Eye 2000; 14: 635-41.
5. Ring EFJ. Progress in the measurement of human body temperature. IEEE Eng Med Biol Mag 1998; 17: 19-24.
6. Gratt BM, Anbar M. Thermology and facial telethermography: Part II. Current and future clinical applications in dentistry. Dentomaxillofac Radiol 1998; 27: 68-74.
7. Keyserlingk JR, Ahlgren PD, Yu E, Belliveau N, Yassa M. Functional infrared imaging of the breast. IEEE Eng Med Biol Mag 2000; 19: 30-41.
8. Harding JR. Investigating deep venous thrombosis with infrared imaging. IEEE Eng Med Biol Mag 1998; 17: 43-6.
9. Fushimi H, Kubo M, Inoue T, Yamada Y, Matsuyama Y, Kameyama M. Peripheral vascular reactions to smoking – profound vasoconstriction by atherosclerosis. Diabetes Res Clin Pract 1998; 42: 29-34.
10. Purslow C, Wolffsohn JS. Ocular surface temperature. A review. Eye Contact Lens 2005; 31: 117-23.
11. Morgan PB, Tullo AB, Efron N. Infrared thermography of the tear film in dry eye. Eye 1995; 9: 615-8.
12. Morgan PB, Tullo AB, Efron N. Ocular surface cooling in dry eye – A pilot study. J BCLA 1996; 19: 7-10.
13. Fujishima H, Toda I, Yamada M, Sato N, Tsubota K. Corneal temperature in patients with dry eye evaluated by infrared thermometer. Br J Ophthalmol 1996; 80: 29-32.
14. Mapstone R. Corneal thermal patterns in anterior uveitis. Br J Ophthalmol 1968; 52: 917-21.
15. Bogdasarov IB, Lenskaia OP, Belkina BM. Thermography in the diagnosis of retinoblastoma in children. Med Radiol 1985; 30: 19-21.
16. Corvi A, Innocenti B, Mencucci R. Thermography used for analysis and comparison of different cataract

surgery procedures based on phacoemulsification. Physiol Meas 2006; 27: 371-84.
17. Maldonado-Codina C, Morgan PB, Efron N. Thermal consequences of photorefractive keratectomy. Cornea 2001; 20: 509-15.
18. Horven I. Corneal temperature in normal subjects and arterial occlusive disease. Acta Ophthalmol 1975; 53: 863-74.
19. Auker CR, Parver LM, Doyle T, Carpenter DO. Choroidal blood flow. I. Ocular tissue temperature as a measure of flow. Arch Ophthalmol 1982; 100: 1323-6.
20. Girardin F, Orgül S, Erb C, Flammer J. Relationship between corneal temperature and finger temperature. Arch Ophthalmol 1999; 117: 166-9.
21. Morgan PB, Smyth JV, Tullo AB, Efron N. Ocular temperature in carotid artery stenosis. Optom Vis Sci 1999; 76: 850-4.
22. Gugleta K, Orgül S, Flammer J. Is corneal temperature correlated with blood-flow velocity in the ophthalmic artery? Curr Eye Res 1999; 19: 496-501.
23. Hayreh SS, Zimmerman B, Podhajsky P. Incidence of various types of retinal vein occlusion and their recurrence and demographic characteristics. Am J Ophthalmol 1991; 117: 429-41.
24. Risk factors for branch retinal vein occlusion. The Eye Disease Case-Control Study Group. Arch Ophthalmol 1993; 104: 34-41.
25. Risk factors for central retinal vein occlusion. The Eye Disease Case-Control Study Group. Arch Ophthalmol 1996; 114: 545-54.
26. Williamson TH. Central retinal vein occlusion: what's the story? Br J Ophthalmol 1997; 81: 698-704.
27. Hayreh SS, Zimmerman B, McCarthy MJ, Podhajsky P. Systemic diseases associated with various types of retinal vein occlusion. Am J Ophthalmol 2001; 131: 61-77.
28. Ciardella AP, Clarkson JG, Guyer DR, Renno RZ, Yannuzzi LA. Occlusione della vena centrale della retina. In: Guyer DR, Yannuzzi LA, Chang S, Shields JA, Green WR, eds. Retina, Vitreo, Macula, vol. 1. Rome: Verduci, 2000; 255-69.
29. Clarkson JG. Central retinal vein occlusion. In: Ryan SJ, ed. Retina, vol. 2. St. Louis: CV Mosby, 1989; 421-6.
30. Filkenstein D. Branch retinal vein occlusion. In: Ryan SJ, ed. Retina, vol. 2. St. Louis: CV Mosby, 1989; 427-32.
31. Janssen MC, den Heijer M, Cruysberg JR, Wollersheim H, Bredie SJ. Retinal vein occlusion: a form of venous thrombosis or a complication of atherosclerosis? A meta-analysis of thrombophilic factors. Thromb Haemost 2005; 93: 1021-6.
32. Adamczuk YP, Iglesias Varela ML, Martinuzzo ME, Cerrato GS, Forastiero RR. Central retinal vein occlusion and thrombophilia risk factors. Blood Coagul Fibrinolysis 2002; 13: 623-6.
33. Fegan CD. Central retinal vein occlusion and thrombophilia. Eye 2002; 16: 98-106.
34. Marcucci R, Bertini L, Giusti B, et al. Thrombophilic risk factors in patients with central retinal vein occlusion. Thromb Haemost 2001; 86: 772-6.
35. Hayreh SS. Classification of central retinal vein occlusion. Ophthalmology 1983; 90: 458-74.
36. Hayreh SS. Management of central retinal vein occlusion. Ophthalmologica 2003; 217: 167-88.
37. Coscas G, Dhermy P. Physiopathologie des occlusions veineuses rétiniennes. In: Coscas G, Dhermy P, eds. Occlusions Veineuses Rétiniennes. Paris: Masson, 1978; 77-110.
38. Hayreh SS. Retinal vein occlusion. Ind J Ophthalmol 1994; 42: 109-32.
39. A randomized clinical trial of early panretinal photocoagulation for ischemic central vein occlusion. The Central Vein Occlusion Study Group N report. Ophthalmology 1995; 102: 1434-44.
40. Hayreh SS, Rubenstein L, Podhajsky P. Argon laser scatter photocoagulation in treatment of branch retinal vein occlusion. A prospective clinical trial. Ophthalmology 1993; 206: 1-17.
41. Tranquart F, Arsene S, Giraudeau B, et al. Initial color Doppler findings in retinal vein occlusion. J Clin Ultrasound 2000; 28: 28-33.
42. Arsene S, Giraudeau B, Le Lez ML, Pisella PJ, Pourcelot L, Tranquart F. Follow up by colour Doppler imaging of 102 patients with retinal vein occlusion over 1 year. Br J Ophthalmol 2002; 86: 1243-7.
43. Ozbek Z, Saatci AO, Durak I, et al. Colour Doppler assessment of blood flow in eyes with central retinal vein occlusion. Ophthalmologica 2002; 216: 231-4.