Ocular Blood Flow Parameters in Patients with Rhegmatogenous Retinal Detachment

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A B S T R A C T

The aim of the present study is to evaluate the potential statistically significant differences in the ocular blood flow parameters in eyes with rhegmatogenous retinal detachment (RD). Eleven patients, 5 females and 6 males, mean age 46 years (range 22–70), with the unilateral rhegmatogenous RD were enrolled in the study. Colour Doppler Ultrasound was used to measure ocular blood flow velocities in the ophthalmic artery (OA), posterior ciliary's arteries (PCA) and ophthalmic vein (OV). The contralateral eye served as a control. All Doppler examinations were performed 1 day before and exactly 3 days after the retinal detachment surgery. The measurements of the peak systolic velocity (V_{max}), diastolic velocity (V_d), minimum velocity (V_{min}), time-averaged velocity (TAV), resistive index (RI) and pulsatility index (PI) showed no statistically significant difference (by paired Student's t-test, p>0.05) between the OA, PCA and OV in healthy eyes and eyes with RD before operation, as well as between the eyes with RD before and after the operation. Only was increased RI in OV of eyes with RD after the surgery (p<0.05). All these parameters were not related with 2 or more quadrants of RD, but the difference in duration of retinal detachment in days is statistically significant (by Wilcoxon t-test p>0.05). Pearson correlation method gave statistically significant correlation between RI and PI of the OA in healthy eyes (r =0.826, p<0.01), eyes with RD before operation (r =0.847, p<0.01) and eyes with RD after the operation (r=0.856, p<0.01). Formula for the calculation of PI by RI was derived using linear regression analysis in all three cases. Scleral buckling surgery leaves the ocular blood parameters in OA unchanged. The correlation between RD and logarithm of duration of RD in days is statistically significant.

Key words: *retinal detachment, Colour Doppler ultrasonography, resistive index, pulsatility index, ophthalmic artery*

Introduction

Colour Doppler ultrasonography is broadly applied in ophthalmology.[1–3] Some recent studies showed the decrease in the ocular blood flow parameters in both eyes in patients with rhegmatogenous retinal detachment (RD), compared to healthy patients.[4] Also some studies suggested that scleral buckling surgery decrease velocities and blood flow in retinal artery (RA), posterior ciliary's arteries (PCA) and ophthalmic (OA) artery which may explain a possible macular dysfunction in the operated eyes.[5, 6] In the same time some other studies found no increased resistance of the flow in the ophthalmic artery and central artery of the retina of the operated eyes.[7,8] The aim of the present study is to evaluate the potential statistically significant differences in the ocular blood flow parameters between healthy eyes and eyes with RD before operation, as well as in the eye before and after the scleral buckling surgery.

Patients and Methods

Eleven patients, 5 females and 6 males, mean age 46 years (22–70), with the RD were enrolled in the study. Patients with other eye diseases (glaucoma, uveitis, diabetic retinopathy, previous operative treatment) as well as systemic diseases were excluded from the study. Retinal detachment surgery was performed by conventional technique using encircling band.[9–11] Colour Doppler Ultrasound was used to measure ocular blood flow velocities in the ophthalmic artery (OA), ciliary's artery (CA) and ophthalmic vein (OV). All Doppler examinations

were performed 1 day before and exactly 3 days after the scleral buckling surgery. Doppler ultrasonography was performed using General Electric Logiq 500 machine with probe frequency range 6–9 MHz (7.0 MHz). The examination technique and intra-individiual variation have been described previosly.[12]

The maximum velocity (V_{max}) was the peak of flow velocity. The minimum velocity (V_{min}) was in more than 83% measurements equal to diastolic velocity (V_d) and in less then 17% cases $V_{min} \approx V_d$ so we omit V_{min} from further observation. The time-averaged velocity (TAV) was automatically calculated by the computer software of the ultrasound apparatus. The resistive index RI and pulsatility index PI were also calculated by the same software in the following way:

$$RI = \frac{V_{max} - V_d}{V_{max}} \quad , \quad PI = \frac{V_{max} - V_d}{TAV}$$

All results are presented as arithmetic means ± standard deviation (SD). Differences between groups were analysed with the unpaired Student's t-test and Wilcoxon t-test. P-values <0.05 were considered statistically significant. Pearson correlation method is used for correlation (r) calculation. Statistical analysis was achieved with SPSS 11.01 on a Pentium 4 computer.

Results

Eleven patients, 5 females and 6 males, mean age 46 years (22–70), with the rhegmatogenous RD were enrolled in the study. Clinical characteristics of patients are presented in Table 1. When the patients are separated in two groups with respect to retinal detachment ≥2 quadrants or <2 quadrants, there were no statistically significant differences between groups in sex, age or myopia, but the difference in duration of retinal detachment in days is statistically significant (Table 2).

There is no correlation between retinal detachment (in quadrants) and age of patients (r=0.112), and correlation between retinal detachment and myopia is very small (r=0.212). But, correlation between retinal detachment (RD) and logarithm of duration of retinal detachment in days (log DU) is very significant (r=0.701) and the regression formula is

$$RD = 0.358 \times \log DU + 0.118$$

TABLE 1
CLINICAL CHARACTERISTICS OF PATIENTS

	All patients
N	11
Sex M/F	6/5
Age	46.3±15.8
Myopia	−4.1±5.5
Retinal detachment	0.47±0.15
Duration of retinal detachment in days	12±7.96

TABLE 2
CLINICAL CHARACTERISTICS OF PATIENTS WITH RETINAL DETACHMENT ≥2 QUADRANTS, AND PATIENTS WITH RETINAL DETACHMENT <2 QUADRANTS

	Patients with RD ≥0.5	Patients with RD <0.5
N	7	4
Sex M/F	4/3	2/2
Age	45.7±16.2	47.5±17.6
Myopia	−3.8±6.5	−4.5±3.7
Retinal detachment	0.56±0.09	0.31±0.08*
Duration of RD in days	16±7.28	5±1.63*

* P<0.05 compared to values in patients with RD ≥0.5; RD – retinal detachment

Table 3 summarizes ocular blood flow parameters for healthy eyes and eyes with RD before operation. Ocular blood flow parameters for eyes with RD before operation and after the operation are presented in Table 4. No statistically significant differences between these groups were found except statistically significant difference of RI in ophthalmic vein. There is no statistically significant difference in ocular blood flow parameters in OA of eyes with RD before operation in relation with 2 or more quadrants of RD (Table 5). In relation with ten or more days of duration of RD there are no statistically significant differences of ocular blood flow parameters in OA of eyes with RD before operation (Table 6). Correlations between RI (independent variable) and PI (dependent variable) of the OA in healthy eyes, eyes with RD before operation and eyes with RD after the operation are presented in Table 7. Table 8. summarizes correlations between V_{max}, V and TAV of the OA in healthy eyes, eyes with RD before operation and eyes with RD after the operation.

TABLE 3
OCULAR BLOOD FLOW PARAMETERS FOR HEALTHY EYES AND EYES WITH RD BEFORE OPERATION (MEANS±SD)

	N	Healthy eyes	Eyes with RD
OA, V_{max}	11	39.87±12.25	39.10±13.31
OA, V_d	11	10.05±3.40	9.54±4.31
OA, TAV	11	18.90±5.48	17.91±6.35
OA, RI	11	0.739±0.072	0.743±0.066
OA, PI	11	1.590±0.473	1.607±0.324
CA, V_{max}	11	35.40±16.13	28.23±16.26
CA, V_d	11	11.29±5.18	10.58±5.15
CA, RI	11	0.673±0.060	0.614±0.049
OV, V_{max}	11	9.29±4.35	12.43±9.44
OV, V_d	11	7.33±3.10	9.45±5.88
OV, RI	11	0.190±0.163	0.190±0.104

SD – standard deviation; RD – retinal detachment, OA – ophthalmic artery, CA – ciliary artery, OV – ophthalmic vein, V_{max} – maximum velocity, V_d – diastolic velocity, TAV – time-averaged velocity, RI – resistive index, PI – pulsatility index.

TABLE 4

OCULAR BLOOD FLOW PARAMETERS FOR EYE WITH RD BEFORE AND AFTER THE OPERATION (MEANS±SD)

	N	Eyes with RD before the operation	Eyes with RD after the operation
OA, V_{max}	11	40.40±14.19	40.29±18.46
OA, V_d	11	9.63±4.76	10.65±4.41
OA, TAV	11	18.21±6.88	19.37±7.36
OA, RI	11	0.747±0.071	0.724±0.050
OA, PI	11	1.635±0.338	1.500±0.283
CA, V_{max}	11	33.27±11.00	25.03±10.26
CA, V_d	11	11.88±3.28	8.93±4.64
CA, RI	11	0.636±0.064	0.656±0.094
OV, V_{max}	11	14.28±10.97	8.74±5.16
OV, V_d	11	10.57±6.84	5.94±3.01
OV, RI	11	0.205±0.108	0.285±0.108*

* $P<0.05$ compared to eyes with RD before operation, SD – standard deviation; RD – retinal detachment, OA – ophthalmic artery, CA – ciliary artery, OV – ophthalmic vein, V_{max} – maximum velocity, V_d – diastolic velocity, TAV – time-averaged velocity, RI – resistive index, PI – pulsatility index.

Discussion

Comparing the results of the peak systolic velocity (V_{max}), diastolic velocity (V_d), minimum velocity (V_{min}), time-averaged velocity (TAV), resistive index (RI) and pulsatility index (PI) showed no statistically significant difference (by paired Student's T test, $p>0.05$) between the OA, PCA and OV in healthy eyes and eyes with RD before operation, as well as between the eyes with RD before and after the operation except in one case. RI in OV of eyes with RD was increased after the surgery ($p<0.05$). Value of RI in veins depends of variety of factor, in this cases postoperative oedema, so that could explain the statistically significant difference of RI.[12] After the fifteen days of surgery there were no statistically significant differences in value of RI in OV which confirm role of postoperative oedema. Our results differ from those in study of Santos et al. who found changes of ocular blood parameters in OA after the surgery.[6] His study carried out 12 patients with RD and he found statistically significant reductions in V_{max} and TAV. Our results are similar with the studies of Hanioglu-Kargi et al. and Regillo et al. who found no statistically significant difference in OA parameters. Regillo et al. have demonstrated in their prospective, controlled study which included six patients no significantly change in OA parameters after the scleral buckling surgery.[5] Hanioglu-Kargi et al. confirmed these results in study which included twenty-five patients.[7]

When the patients are separated in two groups with respect to retinal detachment ≥2 quadrants or <2 quadrants, there were no statistically significant differences between groups in sex, age or myopia, but the difference in duration of retinal detachment in days is statistically

TABLE 5

OCULAR BLOOD FLOW PARAMETERS IN OA OF EYES WITH RD BEFORE OPERATION IN RELATION WITH 2 OR MORE QUADRANTS OF RD (MEANS±SD)

	RD ≥0.5	RD <0.5
N	7	4
V_{max}	43.63±14.38	31.19±6.78
V_d	10.04±5.3	8.66±2.02
TAV	19.2±7.17	15.66±4.58
RI	0.755±0.08	0.722±0.026
PI	1.695±0.138	1.454±0.093

SD – standard deviation; RD – retinal detachment, OA – ophthalmic artery, V_{max} – maximum velocity, V_d – diastolic velocity, TAV – time-averaged velocity, RI – resistive index, PI – pulsatility index.

TABLE 6

OCULAR BLOOD FLOW PARAMETERS IN OA OF EYES WITH RD BEFORE OPERATION IN RELATION WITH 10 OR MORE DAYS OF DURATION OF RD (MEANS±SD)

	Duration of RD ≥10 days	Duration of RD <10 days
N	6	5
V_{max}	45.06±15.2	31.96±6.16
V_d	10.43±5.7	8.47±1.8
TAV	19.32±7.84	16.23±4.17
RI	0.751±0.087	0.734±0.035
PI	1.711±0.397	1.483±0.173

SD – standard deviation; RD – retinal detachment, OA – ophthalmic artery, V_{max} – maximum velocity, V_d – diastolic velocity, TAV – time-averaged velocity, RI – resistive index, PI – pulsatility index.

TABLE 7

CORRELATIONS BETWEEN RI (INDEPENDENT VARIABLE) AND PI (DEPENDENT VARIABLE) OF THE OA IN HEALTHY EYES, EYES WITH RD BEFORE OPERATION AND EYES WITH RD AFTER THE OPERATION

	Correlation r	Linear regression formula
OA in healthy eyes	0.826*	PI=5.395×RI–2.4
OA in eyes with RD before the operation	0.847*	PI=4.180×RI–1.499
OA in eyes with RD after the operation	0.856*	PI=4.763×RI–1.946

* $P<0.01$; D – retinal detachment, OA – ophthalmic artery, V_{max} – maximum velocity, V_d – diastolic velocity, TAV – time-averaged velocity, RI – resistive index, PI – pulsatility index.

significant (Wilcoxon t-test $p>0.05$). The worse the characteristics of the RD, duration of RD had been longer. Also, ocular blood flow parameters in OA of eyes with RD before operation in relation with 2 or more quad-

rants of RD did not show statistically significant difference. Comparing the ocular blood flow parameters in OA of eyes with RD before operation in relation with 10 or more days of duration of RD we have not found statistically significant difference. In study of Pallares et al. OA ocular blood parameters were compared in sixty patients with respect of 2 or more quadrants of RD and duration of RD (fifteen days).[4] They found statistically significant difference in velocity. Our results showed difference tendency but there were not statistically significant. That could give interesting information about time-interval when changes in parameters become significant because that could have influence on functional results. Also, Pearson correlation method gave statistically significant correlation between RI and PI of the OA in healthy eyes (r=0.826, p<0.01), eyes with RD before operation (r=0.847, p<0.01) and eyes with RD after the operation (r=0.856, p<0.01). Formula for the calculation of PI by RI was derived using linear regression analysis in all three cases.

RI as an independent variable and PI as a dependent variable became more influenced by each other in patients with RD and the most in patients after the surgery. At the same time, correlations between V_{max}, V_d

TABLE 8

CORRELATIONS BETWEEN V_{MAX}, V_D AND TAV OF THE OA IN HEALTHY EYES, EYES WITH RD BEFORE OPERATION AND EYES WITH RD AFTER THE OPERATION

	V_{max} & TAV	V_{max} & V_d	TAV & V_d
Healthy eyes	r=0.800**	r=0.602	r=0.875**
Eyes with RD before operation	r=0.810**	r=0.608*	r=0.894**
Eyes with RD after operation	r=0.958**	r=0.952**	r=0.920**

* P<0.05, ** P<0.01, r – correlation; RD – retinal detachment, OA – ophthalmic artery, V_{max} – maximum velocity, V_d – diastolic velocity, TAV – time-averaged velocity

and TAV of the OA in healthy eyes, eyes with RD before operation and eyes with RD after the operation were statistically significant increased. It seems, that the scleral buckling surgery augments correlation between velocities in OA due to influence on microvascular autoregulatory mechanism. This results raise need for further investigation in future.

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HEMODINAMSKI PARAMETRI KOD OKA S MREŽNIČNIM ODLJEPLJENJEM

S A Ž E T A K

Cilj našeg istraživanja bio je utvrditi da li postoji statistički značajna razlika u hemodinamskim parametrima između zdravog oka i oka sa mrežničnim odljepljenjem. U istraživanje je bilo uključeno 11 bolesnika, 5 žena i 6 muškaraca, srednje dobi 46 godina (raspon 22–70), sa jednostranim mrežničnim odljepljenjem. Brzine krvnog protoka u oftalmičnoj arteriji, stražnjim cilijarnim arterijama i oftalmičnoj veni su mjerene ultrazvukom (Colour Doppler Ultrasound). Drugo, zdravo oko bolesnika je služilo kao kontrola. Ultrazvučna mjerenja provedna su jedan dan prije i tri dana poslije konvencionalne operacije mrežničnog odljepljenja. Nije bilo statistički značajne razlike u vrijednostima vršne sistoličke brzine (V_{max}), dijastoličke brzine (V_d), minimalne brzine (V_{min}), srednje brzine (TAV), indeksa otpora (RI) i indeksa pulsatilnosti (Student's T test, p>0,05) između oftalmične arterije, stražnjih cilijarnih arterija i oftalmične vene kod zdravog oka i oka sa mrežničnim odljepljenjem prije operacije. Isto tako, nije bilo statistički

značajne razlike između istih parametara kod oka sa mrežničnim odljepljenjem prije i poslije operacije. Vrijednosti indeksa otpora u oftamičnim venama nakon operacije u odnosu na preoperativne je bio značajno povišen (p<0,05). Svi ispitivani parametri nisu u korelaciji sa opsegom mrežničnog odljepljenja (2 ili više kvadranata), ali postoji statistička značajna razlika u vrijednostima parametara obzirom na trajanje mrežničnog odljepljenja (Wilcoxon T-test p>0,05). Korelacijskom metodom po Pearson-u dobivena je statistički značajna korelacija između indeksa otpora i indeksa pulsatilnosti u oftalmičnoj arteriji u zdravom oku (r=0,826, p<0,01), oku s mrežničnim odljepljenjem prije operacije (r=0,847, p<0,01) i oku s mrežničnim odljepljenjem nakon operacije (r=0,856, p<0,01). Formula za izračunavanje indeksa pulsatilnosti s indeksom otpora je dobivena korištenjem linearne regresijske analize u sva tri slučaja. Konvencionalna operacija mrežničnog odljepljenja ne mijenja hemodinamske parametre u oftalmičnoj arteriji. Korelacija između mrežničnog odljepljenja i logaritma trajanja mrežničnog odljepljenja u danima je statistički značajna.