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Ocular circulatory changes following scleral buckling procedures

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Abstract

The effect of segmental scleral buckling (SB) on ocular circulation was evaluated by measurements of the ocular pulse amplitude (PA) and the ophthalmic artery pressure (OAP). In this study the OAP was defined as the intraocular pressure (IOP) at which the PA disappeared during increasing IOP. Twenty four patients with unilateral rhegmatogenous retinal detachment who underwent SB of varying extent were studied; the unoperated fellow eyes served as controls. Both the OAP and the ophthalmic perfusion pressures (OAP minus IOP) decreased significantly ($p<0.01$) as the area of SB treatment increased. Follow-up measurements showed that the OAP was relatively lower up to 3 months postoperatively than after 3 months, and then remained stable. Our results indicated that SB affects the ocular pulse measurements and may decrease ocular blood flow because of decreased ophthalmic perfusion pressure, probably due to increased choroidal vascular resistance, and that the greater the extent of the SB treatment, the greater the possibility of decreased ocular blood flow.

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Scleral buckling (SB) is a well-established surgical technique for treating rhegmatogenous retinal detachment. The rates of retinal reattachment are satisfactory but complications, although rare, do occur.

It is important to determine whether SB affects the ocular circulation. Using the laser Doppler method in humans Yoshida *et al*[1] reported reduced retinal blood flow in eyes subjected to SB, which was thought to be one cause of postoperative complications. Diddie and Ernest,[2] using the microsphere technique, found that encircling decreased choroidal circulation in rabbit eyes. Mano[3] also reported that choroidal blood flow in rabbit eyes, measured by the hydrogen clearance method, decreased as the degree of constriction applied in the encircling operation increased. Dobbie[4] found decreased ocular pulse amplitude (PA) in eyes that had undergone SB with encircling and speculated that the encircling was responsible for postoperative circulatory alterations. However his speculation was based only on pulse amplitude changes, and uncertainty still remains. More importantly, the effects of segmental SB on ocular circulation in human eyes has not been reported.

In the current study we performed ocular pulse measurements[5-7] in patients who had undergone various degrees of segmental SB. We measured the ophthalmic artery pressure (OAP), defined here as the intraocular pressure (IOP) at which the PA disappeared during increasing IOP, and calculated the ophthalmic perfusion pressure as the difference between it and IOP. The significant correlation between ophthalmic perfusion pressure and the extent of the segmental SB procedure is now disclosed for the first time.

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Patients and methods

PATIENTS

The study population comprised 24 patients who underwent SB for unilateral rhegmatogenous retinal detachment (Table 1). Informed consent was obtained from all subjects. All operations were performed by the same surgeon (AY), using general anaesthesia, the same materials (No 276 solid silicone tyre and No 40 encircling silicone band, Mira, Waltham, MA, USA), and the same technique (Schepens implant[8]). No vortex veins were sacrificed and no rectus muscles were removed. No complications arose during SB surgery, and the retinas were reattached completely with a single operation. The fellow eyes were not treated. The treated eyes were classified into subgroups A, B, and C which had SB involving one, two, and three or more quadrants, respectively. In four cases, one each in subgroups A and B and two in subgroup C, postoperative mild choroidal detachment developed although there was no surgical occlusion of the vortex vein. The postoperative refractive difference between the treated eye and the healthy fellow eye was within 3 dioptres in all cases.

METHODS

The ocular pulse was recorded at the corneal surface using the ocular cerebral vascular monitor (Digilab, Cambridge, MA, USA) developed by Langham and co-workers[5-7]; we added a highly sensitive amplifier (Sanei, Tokyo, Japan). Figure 1 shows a typical pulse amplitude (PA) wave recorded from an unoperated eye of one patient (IOP=14 mm Hg).

Pressure was applied gradually to the sclera of the eye using a Langham pressure cup system (Digilab). The PA and the IOP were monitored simultaneously. Because the PA was expected to

Table 1 Characteristics of patients

Age (range, years)	20–69	
mean (SD)	51·2 (17·1)	
Male: female	14:10	
Extent of scleral buckling procedure	1 quadrant:	8 cases (subgroup A)
	2 quadrants:	9 cases (subgroup B)
	≥3 quadrants:	7 cases (subgroup C)

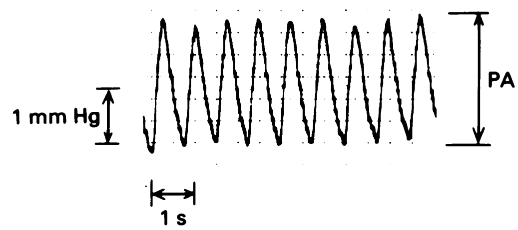

Figure 1 Typical ocular pulse recorded from an unoperated eye of one patient. PA=pulse amplitude.

disappear when the IOP was equal to the systolic OAP, we defined the OAP as the IOP at which the PA disappeared.[6] Figure 2 shows the changes in PA obtained from the same eye as shown in Figure 1 when the IOP was increased. The PA decreased as the IOP increased, and disappeared when the IOP reached 68 mm Hg. In this example, therefore, the OAP was 68 mm Hg.

The PA and the OAP were measured in both eyes of all subjects at 1, 2, 3, 6, 9, and 12 months postoperatively. To minimise variations due to individual differences the untreated fellow eyes served as controls. The PA and OAP ratios were calculated as follows:

PA ratio=PA of treated eye/PA of control fellow eye

OAP ratio=OAP of treated eye/OAP of control fellow eye

The ophthalmic perfusion pressure[6] was calculated as the difference between the OAP and the IOP. We did not calculate the pulsatile ocular blood flow[9] because the pressure-volume relationship[6] may be changed in SB eyes.

The data were analysed using standard statistical methods. Analysis of variance was performed among the groups. Student's t test was performed between group comparisons. Differences were considered significant when the probability value indicated a chance of random occurrence of less than 5%.

Results

Six months after SB the PA of the SB eye was lower in every case than that of the healthy fellow eye. The mean PA (SD) of the SB eyes (0·7 (0·3) mm Hg) was significantly lower ($p<0·001$) than that of the healthy fellow eyes (1·5 (0·6) mm Hg). The mean PA ratio was 0·43 (0·16) at 6 months after the SB. The PA ratio decreased significantly ($p<0·05$) in direct proportion to the extent of the segmental SB procedure (Fig 3) by the analysis of variance.

The OAP of the SB eye 6 months after SB was also lower in every case than that of the fellow eye. The mean OAP of the SB eyes (43·2 (11·8)

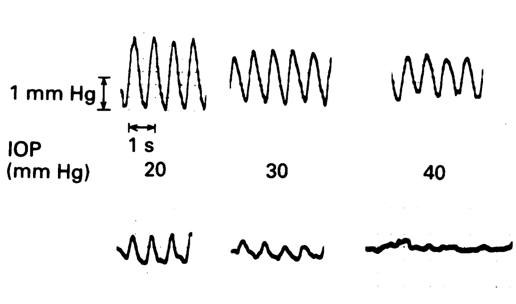

Figure 2 Changes in pulse amplitude obtained from the eye shown in Figure 1 during increased intraocular pressure (IOP). The pulse amplitude disappeared when the IOP reached 68 mm Hg, which was taken as the ophthalmic artery pressure.

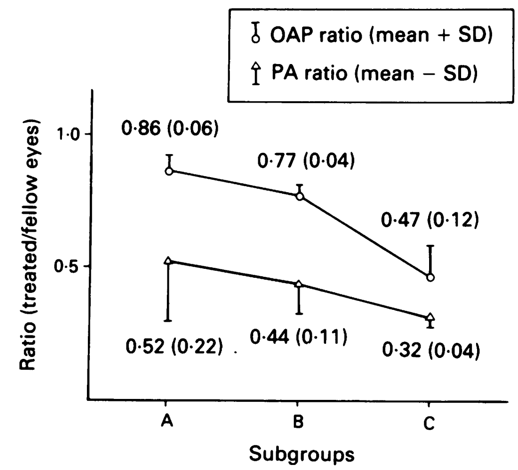

Figure 3 Pulse amplitude (PA) ratio and ophthalmic artery pressure (OAP) ratio 6 months postoperatively for subgroups A, B, and C.

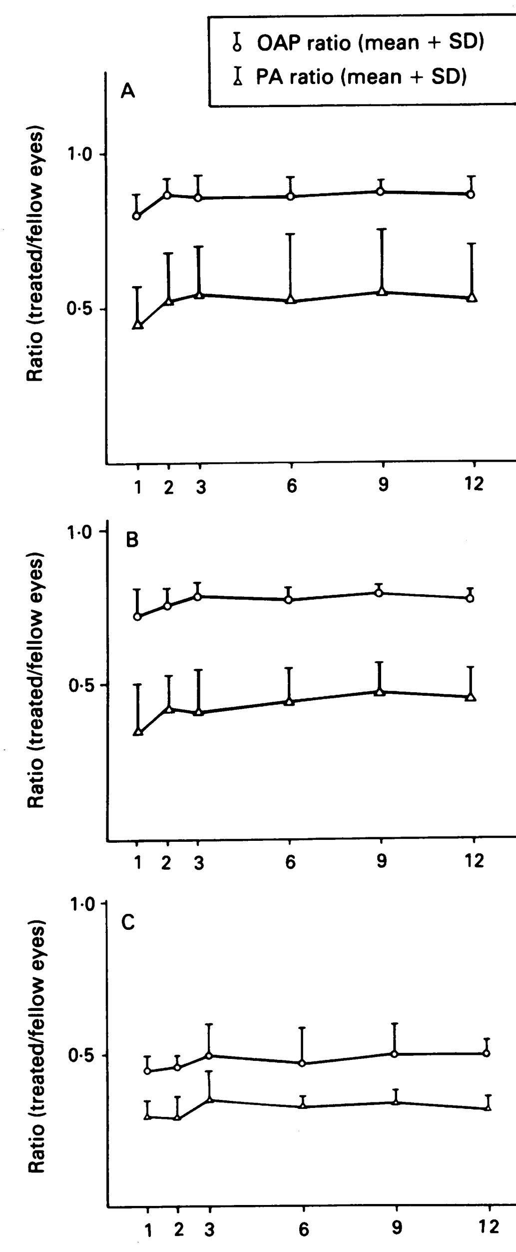

Figure 4 Changes in pulse amplitude (PA) ratio and ophthalmic artery pressure (OAP) ratio subsequent to segmental scleral buckling (SB). A one quandrant of SB in subgroup A (n=8); B two quadrants of SB in subgroup B (n=9); C three or more quadrants of SB in subgroup C (n=7).

mm Hg) was significantly lower ($p<0.001$) than that of the fellow eyes (61·0 (5·4) mm Hg) 6 months after SB. The mean OAP ratio at 6 months after SB was 0·71 (0·18). Little variation existed in the OAP ratio within each subgroup, and this ratio also decreased significantly ($p<0.01$) in direct proportion to the extent of SB by the analysis of variance (Fig 3). A statistically significant difference in the ratio also was seen between subgroups A and B ($p<0.005$) and subgroups B and C ($p<0.0001$).

The ophthalmic perfusion pressure of SB eyes 6 months after SB (29·0 (11·0) mm Hg) was significantly ($p<0.0001$) lower than that of the fellow eyes (42·0 (5·6) mm Hg). These values (mm Hg) 6 months after SB were 38·8 (6·6) in subgroup A, 31·3 (3·1) in subgroup B, and 14·7 (5·6) in subgroup C. The ophthalmic perfusion pressure decreased significantly ($p<0.01$) in direct proportion to the extent of the segmental SB procedure by the analysis of variance.

Changes in the PA and OAP ratios over time are shown in Figure 4. Both ratios tended to be lower 1 to 2 months after SB in all subgroups, then stabilised 3 months postoperatively with virtually no further changes occurring up to 12 months postoperatively. Four cases of mild choroidal detachment occurred postoperatively in subgroups A (one), B (one), and C (two) in which the PA and OAP decreased more than the others in the same subgroup until 3 months postoperatively. Ophthalmoscopically visible choroidal detachment disappeared at 2 months postoperatively in all four cases.

Discussion

We have demonstrated for the first time the relationship between the extent of segmental SB and postoperative ocular circulatory changes. The OAP, as defined in this study, as well as the PA were lower in the SB eyes than in the untreated fellow eyes. The calculated ophthalmic perfusion pressure values were also lower in the SB eyes than in the fellow eyes. Moreover, these three parameters in SB eyes significantly decreased with increasing area of SB treatment, indicating that SB eyes may have lower total ocular blood flow as the SB area increases. This decrease of both OAP and ophthalmic perfusion pressure in SB eyes, compared with the fellow eyes, observed under the same systemic blood pressure in the same person, implies an increase in vascular resistance in the SB eyes due to the surgical procedure.

Our findings of decreased ocular blood flow in human SB eyes are consistent with those of Diddie and Ernest[2] and Mano,[3] who reported decreased choroidal blood flow after SB in rabbits. It has been suggested that venous drainage obstruction (resulting in increased vascular resistance) caused by pressure induced by SB on the vortex vein in the sclera or choroid leads to the decreased blood flow. Using an ocular pulse measurement similar to ours, Dobbie[4] suggested that the decreased ocular circulation resulted from the encircling procedure. However, the amplitude of the ocular pulse itself can be affected not only by ocular circulation changes but also by ocular rigidity changes.[4,10] Thus, we specifically added another measurement, the OAP as defined here.

Our results indicate that SB affects the ocular pulse measurements and may decrease ocular blood flow because of decreased ophthalmic perfusion pressure (calculated as the difference between the OAP and the IOP). Because OAP can not be measured directly by any available clinical test, we used for this parameter the value of the IOP at which the PA disappeared as defined by Langham and To'mey.[6] Since this is an indirect method for determining OAP, especially based on ocular PA obtained from the operated eye, our values may reflect some artefact and may only appear to be altered.

Nevertheless, our study indicates that ocular blood flow, probably mainly choroidal blood flow (because it constitutes approximately 90% of total ocular flood flow),[11] may decrease after segmental SB and that this decrease seems to be greater if the procedure is more extensive or complicated by choroidal detachment, or both. It is still unclear how this decrease relates to postoperative complications or to changes in postoperative visual function. However, based on our OAP measurements, we at least speculate that as the extent of segmental SB increases, less elevation in IOP would be required to obstruct the choroidal circulation. Thus, for eyes that have undergone relatively extensive SB, adequate care is necessary to ensure that IOP does not increase postoperatively. Although SB is beneficial to achieve retinal reattachment, it is advisable to minimise the extent of the operation as much as possible to avoid complications.

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1 Yoshida A, Feke GT, Green GJ, *et al. Retinal circulatory changes after scleral buckling procedures. Am J Ophthalmol* 1983; 95; 182–8.
2 Diddie KR, Ernest JT. Uveal blood flow after 360° constriction in the rabbit. *Arch Ophthalmol* 1980; **98**: 729–30.
3 Mano T. Choroidal circulation after encircling procedure. I. Immediate effect. *Folia Ophthalmol Jpn* 1982; **33**: 460–7.
4 Dobbie JG. Circulatory changes in the eye associated with retinal detachment and its repair. *Trans Am Ophthalmol Soc* 1980; **78**: 503–66.
5 Langham ME. A new procedure for the analysis of intraocular dynamics in human subjects. *Exp Eye Res* 1963; **2**: 314–24.
6 Langham ME, To'mey KF. A clinical procedure for the measurements of the ocular pulse-pressure relationship and the ophthalmic arterial pressure. *Exp Eye Res* 1978; **27**: 17–25.
7 Sanborn GE, Miller NR, Langham ME, Kumar AJ. An evaluation of currently available noninvasive tests of carotid artery disease. *Ophthalmology* 1980; **87**: 435–9.
8 Schepens CL. *Retinal detachment and allied disease.* Philadelphia: Saunders, 1983; 405–35.
9 Silver DM, Farrel RA, Langham ME, O'Brien V, Schilder P. Estimation of pulsatile ocular blood flow from intraocular pressure. *Acta Ophthalmol (Kbh)* 1989; **67** (suppl 191): 25–9.
10 Johnson MW, Han DP, Hoffman KE. The effect of scleral buckling on ocular rigidity. *Ophthalmology* 1990; **97**: 190–5.
11 Alm A, Bill A. Ocular circulation. In: Moses RA, Hart WM, eds. *Alder's physiology of the eye,* 8th ed. St Louis: Mosby, 1987: 183–203.