CLINICAL SCIENCE

Clinical characteristics of retinal venous occlusions occurring at different sites

P E Beaumont, H K Kang

Br J Ophthalmol 2002;86:572-580

Aims: To identify the contributory factors associated with different sites of occlusion and the presence or absence of optic nerve head swelling (ONHS).

Methods: 874 cases of retinal venous occlusion (RVO) were prospectively examined at a tertiary referral centre and classified according to three defined sites of occlusion: arteriovenous crossing RVO (AV-RVO); optic cup RVO (OC-RVO); and optic nerve sited RVO. Optic nerve sited RVOs were further divided on the basis of presence (ONHS-RVO) and absence (NONHS-RVO) of ONHS. RVOs not occurring at any of the defined sites were grouped as no-site RVO (NS-RVO). Important clinical parameters were compared among four of the five subgroups by multivariate analysis of variance and χ^2 test (NS-RVO excluded).

Results: The overall multivariate analysis of variance for differences in the mean age, systolic and diastolic blood pressure, body mass index, and intraocular pressure (IOP) among the four subgroups were highly significant ($p < 0.0001$). The F ratios indicated that the differences in the mean age and IOP accounted for this statistical trend. The mean age was statistically significantly lower in the ONHS-RVO group compared to the rest of the groups ($p < 0.0001$). The mean age was significantly higher in OC-RVO compared to the AV-RVO group ($p < 0.05$). The mean IOP was significantly higher in OC-RVO than in the rest of the groups ($p < 0.01$ to 0.0001), while it was also higher in the NONHS-RVO group compared to the ONHS-RVO and AV-RVO groups ($p < 0.0001$). The prevalence of primary open angle glaucoma (POAG), sex, laterality, involvement of the fellow eye, smoking and hypertension were compared by χ^2 tests. POAG was significantly more prevalent in the OC-RVO group than in the rest of the groups ($p < 0.0083$), while it was also significantly more prevalent in the NONHS-RVO group compared to AV-RVO or ONHS-RVO ($p < 0.0083$) groups. Smoking was significantly more prevalent in AV-RVO than in the rest of the groups ($p < 0.05$). The proportion of male sex was significantly higher in ONHS-RVO compared to the AV-RVO group ($p < 0.05$). Hypertension was significantly more prevalent in the AV-RVO than in the ONHS-RVO or NONHS-RVO groups ($p < 0.05$).

Conclusion: A new classification of RVO based on the site of occlusion and ONHS has been evaluated. The higher prevalence of hypertension and smoking in AV-RVO suggests a particular importance of cardiovascular risk factors in this group. The association of POAG with CRVO has been confirmed, but only for those cases without ONHS. A distinctive relation between raised IOP and OC-RVO has been demonstrated, suggesting a causal association. RVOs with ONHS tend to occur in younger people, with a higher proportion of males, and a lower prevalence of hypertension and POAG, suggesting that other causal factors may be important in this group. The new scheme resolves the confusion in the literature regarding classification of RVO, and has diagnostic, causal, prognostic, and therapeutic implications.

See end of article for authors' affiliations

Correspondence to:
Paul E Beaumont, 6th
Floor, 187 Macquarie
Street, Sydney, NSW
2000, Australia;
kwonkang@ozemail.com.au

Accepted for publication
14 January 2002

Occlusions of the venous drainage of the retina classically have been divided into branch and central retinal vein occlusions (CRVO). More recently, retinal venous occlusions (RVO) that involve approximately half of the retina have been recognised as a distinct type of RVO,¹ but there is still confusion as to whether this group of RVO are variants of central or branch RVO.²⁻⁵ Only a few studies have compared the clinical characteristics among different types of RVO.⁵⁻¹⁰ Cardiovascular risk factors such as hypertension and diabetes mellitus are important in all types of RVO.⁶⁻⁷ CRVO has been shown to be associated with raised intraocular pressure (IOP) and primary open angle glaucoma (POAG),^{7,8,11,12} but their role in branch retinal vein occlusion (BRVO) is less clear.^{6,12-14} Risk factor profile for hemispheric RVO is suggested to be similar to that of CRVO.^{5,9}

In this study, clinical and demographic parameters have been compared between RVOs classified according to the site of occlusion. The rationale for dividing RVOs by site has been based on the belief that different anatomical sites of occlusion are distinct in terms of their susceptibility to local and systemic stresses, and may determine the mechanism by

which the occlusion is precipitated. In addition to the site, occlusions occurring within the optic nerve were further subdivided on the basis of the presence or absence of optic nerve head swelling (ONHS). A large consecutive series of RVO has been recruited prospectively to identify the contributory factors associated with different site of occlusion and the presence or absence of ONHS.

SUBJECTS AND METHOD

Subjects

This study is a part of a prospective study conducted between January 1976 and December 1990 with aims to investigate the

Abbreviations: AV-RVO, arteriovenous crossing retinal vein occlusion; BRVO, branch retinal vein occlusion; IOP, intraocular pressure; NONHS-RVO, no optic nerve head swelling-retinal vein occlusion; NS-RVO, "no site"retinal vein occlusion; OC-RVO, optic cup retinal vein occlusion; ONHS-RVO, optic nerve head swelling-retinal vein occlusion; POAG, primary open angle glaucoma; RVO, retinal venous occlusion

Figure 1 A flow chart showing the case selection process for the entire project, of which this report is a part. Eleven hundred and ninety four consecutive cases were referred to a tertiary medical retinal centre with a preliminary diagnosis of RVO. Cases were excluded if photographic documentation was inadequate, there were morphological changes in retinopathy due to delay in presentation, or the diagnosis of RVO could not be confirmed by the definitions used in this study. Eight hundred and seventy four cases met the criteria for inclusion into this project. All 874 cases were investigated for clinical and demographic variables and formed the basis for this report. Biochemical and haemorheological investigations were offered to all cases, unless the patient had already been investigated by the referring ophthalmologist, the patient was unable or unwilling to return for the investigations, or the laboratory service was temporarily unavailable at the time of the initial visit. Morphological parameters were investigated in the 651 cases that have undergone laboratory investigations.

clinical, biochemical, and morphological characteristics of RVO. Figure 1 represents an overview of the case selection for the entire project. The present study examined 874 consecutive cases of non-diabetic RVO which satisfied the definitions outlined in our previous report.¹⁵

Investigations

Every patient underwent extensive investigations, which included pre-existing medical, ocular, and family history, ophthalmic and systemic clinical assessment, fundus photography, and fluorescein angiography. The age and sex of the patient and the laterality of the eyes involved were recorded. The height and weight of the patient were measured in metres and kilograms, respectively, using standard metric ruler and scale. Body mass index was calculated from these measurements as $\text{weight}/(\text{height}^2)$. Blood pressure was recorded in mm Hg using a mercury sphygmomanometer after the patient had been seated for at least 15 minutes. The systolic and diastolic pressures were defined to correspond to the first and fifth Korotkoff sounds, respectively. History of medical treatment for hypertension was determined and the patient was defined as hypertensive if the blood pressure was greater than 140/90 mm Hg, or was currently taking medical antihypertensive therapy. The patient was defined as a “smoker” if he or she was smoking regularly at the time of the onset of RVO. IOP was measured in both eyes in mm Hg using the Goldmann applanation tonometer. The eye was defined as having POAG if the condition was diagnosed by an ophthalmologist before the referral to our centre.

Figure 2 Anatomy of the retinal venous system based on the description by Duke-Elder.¹⁶ (1) Terminal retinal venule; (2) retinal venule; (3) minor retinal vein; (4) main retinal vein; (5) papillary vein; (6) central retinal vein.

Loss of data on blood pressure, height, weight, and IOP occurred in a small proportion of the cases through clerical error. In addition, height and weight could not be measured in patients with disability. Patients who arrived with the pupil dilated were excluded from the assessment of the baseline IOP. Smoking history was initially obtained verbally. A questionnaire form was subsequently introduced because the verbal method was found to be unreliable.

Analysis and classification of photographic images

Fundus photography and fluorescein angiography were performed in a standardised manner as described in our previous report.¹⁵ The colour transparencies and the contact films were viewed on a standard light box using stereo and mono magnifying loops. Every case was examined to determine the site of occlusion, and the anatomical vein involved. The fellow eye was examined for evidence of past or concurrent venous occlusion. A single observer (HK), who was masked from other clinical and biochemical data, assessed the entire series.

Identification of the anatomical vein involved

Duke-Elder's¹⁶ classic description of the anatomy of the venous drainage of the retina formed the basis for identifying the occluded vein (Fig 2), and was outlined in detail in our previous report.¹⁵ Briefly, the minor retinal veins converge until one “main retinal vein” is formed in each quadrant. The “superior papillary vein” is formed by the union of superotemporal and superonasal main retinal veins, while the “inferior papillary vein” is formed by the two inferior main retinal veins. The two papillary veins join to form the CRV. In about one fifth of the normal eye, this union takes place within the optic nerve, each papillary vein entering the nerve tissue separately.¹⁷ In this study, the identification of the involved vein was limited to CRV, papillary vein, or branches of the papillary vein.

Classification by the site of occlusion

The site of occlusion was determined by observing the following: abrupt venous calibre change due to the dilatation of the venous segment distal to the occlusion and thinning of the venous segment proximal to the occlusion; distribution of the ischaemic retinopathy, which usually extends distally from the site of occlusion; and focal staining of the vein at the site of occlusion on fluorescein angiography.¹⁸ Collateral veins also help to determine the site of occlusion, but they occur infrequently during the acute stages of RVO.

Three anatomical sites of occlusion have been defined (Fig 3): AV crossing, optic cup, and optic nerve. With AV crossing and optic cup sited RVOs, the vein calibre change is visible unless obscured by haemorrhage, exudates, or oedema. For the purposes of this study, both artery over vein, and vein over artery configurations were included in the same group. Occlusions occurring in the optic nerve were identified by the fact

Figure 3 Four sites of occlusion defined in this study. (1) Arteriovenous crossing on the retina; (2) on the retina but not at an AV crossing or the optic disc; (3) optic cup; (4) optic nerve.

that the vein entered the optic nerve tissue as a dilated vein. For the purposes of this study, RVOs occurring within the optic nerve were further subdivided into optic nerve head swelling (ONHS-RVO) and no optic nerve head swelling (NONHS-RVO) groups. Optic nerve head swelling was defined as an elevation of optic nerve head above the surrounding retina, associated with evidence of oedema, exudate, or haemorrhage on the optic nerve. Blurring of the disc margins without actual elevation of the disc tissue above the surrounding retina was not considered to represent an ONHS. Stereo photographs are essential in determining the presence of the ONHS.

Finally, RVO can occur on the retina but not in association with any of the above anatomical landmarks. These are termed "no site" RVO (NS-RVO). They have been grouped separately since the site of occlusion does not correspond to a known anatomical site.

Comparison of clinical parameters and statistical methods

The clinical parameters were compared among the four main subgroups of RVO. In view of the small number of cases ($n = 21$), the NS-RVO group was excluded from comparative statistical analysis. The data were entered into a personal computer and managed by a database program (Paradox 7.0, Borland International, Scotts Valley, CA, USA). Statistical analyses were performed using a commercially available statistics

package (Statistica version 4.5, Statsoft, Australia). The normality of distribution of continuous data was confirmed qualitatively by examining the histogram, and quantitatively by the Kolmogorov-Smirnov (K-S) test. The mean age, systolic and diastolic pressures, body mass index, and IOP were compared among the groups by multivariate analysis of variance. If the result of the analysis for all effects was statistically significant, the F ratio was then calculated for each parameter to identify the parameters that contributed substantially to the overall statistical significance. Parameters with large F ratio were analysed further by intergroup pairwise comparisons using Scheffe test, which is conservative in terms of type I error and appropriate for unbalanced numbers.¹⁹

Laterality, involvement of the fellow eye, sex, hypertension, POAG, and smoking were compared among the groups using the χ^2 test. If the overall value of χ^2 was significant, the classified groups were compared by calculating the confidence intervals for the difference in proportions between two groups for all six possible pairs of groups. Initially, type I error was controlled by Bonferroni's method, where each χ^2 was considered statistically significant at the level of $p < 0.0083$ (six parameters) and the confidence intervals for the pairwise multiple comparisons calculated at $p < 0.0083$ (six possible pairs).²⁰ The analyses were then repeated without controlling for type I error at $p < 0.05$.

RESULTS

Eight hundred and seventy four eyes of 854 patients were included in this study and the male to female ratio was 465:409 (1.14:1.0 approximately). There were 438 (50.1%) right and 436 (49.9%) left eyes. Twenty (2.3%) patients presented with acute retinopathy in both eyes, while 37 (4.3%) presented with evidence of old RVO in the fellow eye. Both eyes of the 20 patients with acute bilateral presentation were entered into the study.

The mean and standard deviation (SD) of age in the entire series was 64.0 (SD 11.8) years with a range of 24–94 years. The blood pressure was recorded in 867 (99%) cases. The mean systolic pressure was 150.4 (26.0) mm Hg with a range of 90–260 mm Hg, while the mean diastolic pressure was 90.5 (12.5) mm Hg with a range of 50–160 mm Hg. According to the definition of hypertension used in this study, 517 (59.6%) cases of RVO occurred in patients with systemic hypertension. Body mass index was calculated in 792 (91%) cases with a mean of 26.4 (4.3) and a range of 15.7–46.5. Data on IOP were available in 836 (96%) eyes with a mean of 16.6 (4.3) mm Hg and a range of 8–51 mm Hg, after two outliers were excluded. History of POAG was found in 105 (12.0%) eyes. Smoking history was available in 570 cases (65%), of which 131 (23.0%) occurred in those who smoked regularly at the time of the onset of the disease.

Figure 4 Comparison of the mean age (A) and intraocular pressure (B) by Scheffe test among four subgroups of RVO classified according to the site of occlusion (NS-RVO excluded). Overlapping rectangles indicate that the differences are not statistically significant.

Table 1 Comparison of age, blood pressures, body mass index, and intraocular pressure

	Type of RVO	No	Mean (SD)	Range	F ratio
Age (years)	OC-RVO	58	69.0 (13.0)	32 to 87	12.5
	NONHS-RVO	229	65.8 (12.1)	26 to 88	
	AV-RVO	411	64.4 (9.8)	35 to 89	
	ONHS-RVO	155	58.6 (13.5)	24 to 85	
	NS-RVO	21	64.3 (12.6)	35 to 90	
Systolic pressure (mm Hg)	OC-RVO	58	154.2 (30.7)	94 to 260	1.92
	AV-RVO	407	151.7 (25.0)	92 to 250	
	NONHS-RVO	226	150.2 (26.5)	90 to 246	
	ONHS-RVO	155	145.0 (25.7)	100 to 248	
	NS-RVO	21	155.5 (25.4)	114 to 198	
Diastolic pressure (mm Hg)	AV-RVO	407	91.4 (13.0)	50 to 160	2.95
	NONHS-RVO	226	90.5 (12.5)	64 to 134	
	OC-RVO	58	89.8 (11.5)	64 to 112	
	ONHS-RVO	155	87.7 (11.5)	60 to 126	
	NS-RVO	21	95.4 (8.8)	78 to 118	
Body mass index	ONHS-RVO	139	26.8 (4.7)	15.7 to 46.5	1.39
	AV-RVO	378	26.6 (4.3)	18.2 to 46.0	
	NONHS-RVO	207	26.1 (4.2)	16.9 to 44.8	
	OC-RVO	51	25.6 (4.0)	17.4 to 36.0	
	NS-RVO	17	25.6 (2.8)	19.2 to 31.1	
Intraocular pressure (mm Hg)	OC-RVO	58	19.3 (5.5)	11 to 41	19.2
	NONHS-RVO	220	17.6 (5.4)	10 to 51	
	ONHS-RVO	148	16.0 (3.1)	8 to 26	
	AV-RVO	391	15.9 (3.6)	8 to 42	
	NS-RVO	19	16.6 (3.7)	10 to 22	

The mean, standard deviation (SD), and range of age, systolic and diastolic blood pressures, body mass index, and intraocular pressure (IOP) of the five types of RVO. The overall multivariate analysis of variance for the five parameters was highly significant ($p < 0.0001$). The F ratios for each parameter show that the differences in the mean age and IOP account for most of this statistical trend (NS-RVO excluded from analysis). No = number of cases; AV-RVO, arteriovenous crossing RVO; OC-RVO, optic cup RVO; NONHS-RVO, optic nerve sited RVO without ONHS; ONHS-RVO, optic nerve sited RVO with ONHS; NS-RVO, "No site" RVO.

Arteriovenous crossing RVO involved a branch of the papillary vein in all but two cases, which involved the papillary vein. This contrasted with OC-RVO, in which the papillary vein was occluded in 46 (79.3%) cases with the rest involving the branches of the papillary vein. All RVOs occurring within the optic nerve involved either the papillary or central retinal vein. The papillary vein was occluded in 85 (37.1%) cases in the NONHS-RVO group and 26 (16.8%) cases in ONHS group. In the NS-RVO group, two (9.5%) cases involved the papillary vein, with the remainder affecting the branches of the papillary vein.

Table 1 shows the mean, SD, and range of age, systolic and diastolic blood pressures, body mass index, and IOP of the five types of RVO. The overall multivariate analysis of variance for the five parameters compared among the four groups of RVO (NS-RVO excluded) was highly significant (Wilks's lambda = 0.867, $p < 0.0001$). The F ratios suggested that differences in age and IOP account for most of this statistical trend. The mean age was normally distributed in the four groups of RVO (K-S, $p > 0.05$). The distribution of IOP was skewed because of outliers in AV-RVO (64 mm Hg) and OC-RVO (58 mm Hg). The distribution became normal when these two cases were excluded. The outcome of the Scheffe test on age and IOP are summarised in Figure 4. The ONHS-RVO group had a significantly lower ($p < 0.0001$) mean age (58.6 years) than OC-RVO (69.0 years), NONHS-RVO (65.8 years), and AV-RVO (64.4 years) groups. The mean age was found to be significantly higher in the OC-RVO compared to AV-RVO ($p < 0.05$). The mean age in the NS-RVO group was 64.3 years. The mean IOP was significantly higher in OC-RVO (19.3 mm Hg) compared to the rest of the groups ($p < 0.01$ to 0.0001). It was also significantly higher in the NONHS-RVO group (17.6 mm Hg) compared to the ONHS-RVO (16.0 mm Hg) and AV-RVO (15.9

mm Hg) groups ($p < 0.0001$). The mean IOP in the NS-RVO group was 16.6 mm Hg.

In Table 2, prevalence of POAG, sex, laterality, involvement of the fellow eye, smoking, and hypertension are compared. Statistically significant results at the level of $p < 0.0083$ were found in terms of the prevalence of POAG only. The confidence intervals calculated at $p < 0.0083$ for the multiple comparison of the prevalence of POAG are presented graphically in Figure 5A. The analysis showed that POAG was significantly more prevalent in OC-RVO (41.4%) than in the rest of the groups. It was also significantly more prevalent in the NONHS-RVO (19.2%) group compared to AV-RVO (4.9%) or ONHS-RVO (9.7%). The prevalence of POAG in NS-RVO was 9.5%.

Without Bonferroni correction, the differences between the groups in terms of smoking and sex as well as POAG became statistically significant ($p < 0.05$). The overall analysis on hypertension was of borderline statistical significance ($p = 0.056$), but further analysis was performed because its prevalence has been found to differ between "CRVO" and "BRVO" in previous studies.⁸ The confidence intervals calculated at $p < 0.05$ for the differences in the prevalence of these parameters are summarised in Figures 5B–D. There were no new findings with POAG when the analysis was repeated without Bonferroni correction. Smoking (Fig 5B) was found to be significantly more prevalent in AV-RVO (28.7%) than in the OC-RVO (10.8%), ONHS-RVO (17.9%), or NONHS-RVO (18.4%) groups. In the NS-RVO group, five (35.7%) of 14 eyes belonged to regular smokers. The proportion of male sex (Fig 5C) was significantly higher in the ONHS-RVO (63.2%) group compared to AV-RVO (48.7%). In NS-RVO the prevalence of male sex was 38.1%. Hypertension (Fig 5D) was significantly more prevalent in the AV-RVO (63.5%) group than in the

Table 2 Comparison of POAG, sex, laterality, fellow eye involvement, smoking, and hypertension

POAG	No	Present	Absent	p Value
		No (%)	No (%)	
OC-RVO	58	24 (41.4)	34 (58.6)	<0.0001
NONHS-RVO	229	44 (19.2)	185 (80.8)	
ONHS-RVO	155	15 (9.7)	140 (90.3)	
AV-RVO	411	20 (4.9)	391 (95.1)	
NS-RVO	21	2 (9.5)	19 (90.5)	
Sex	No	Male	Female	p Value
		No (%)	No (%)	
ONHS-RVO	155	98 (63.2)	57 (36.8)	0.0171
NONHS-RVO	229	127 (55.5)	102 (44.5)	
OC-RVO	58	32 (55.2)	26 (44.8)	
AV-RVO	411	200 (48.7)	211 (51.3)	
NS-RVO	21	8 (38.1)	13 (61.9)	
Laterality	No	Right eye	Left eye	p Value
		No (%)	No (%)	
NONHS-RVO	229	117 (51.1)	112 (48.9)	0.9495
ONHS-RVO	155	79 (51.0)	76 (49.0)	
AV-RVO	411	202 (49.2)	209 (50.8)	
OC-RVO	58	28 (48.3)	30 (51.7)	
NS-RVO	21	12 (57.1)	9 (42.9)	
Fellow eye	No	Affected	Unaffected	p Value
		No (%)	No (%)	
OC-RVO	58	8 (13.8)	50 (86.2)	0.1869
AV-RVO	411	37 (9.0)	374 (91.0)	
NONHS-RVO	227	17 (7.5)	210 (92.5)	
ONHS-RVO	155	8 (5.2)	147 (94.8)	
NS-RVO	21	7 (33.3)	14 (66.7)	
Smoking	No	Smoker	Non-smoker	p Value
		No (%)	No (%)	
AV-RVO	261	75 (28.7)	186 (71.3)	0.0099
NONHS-RVO	152	28 (18.4)	124 (81.6)	
ONHS-RVO	106	19 (17.9)	87 (82.1)	
OC-RVO	37	4 (10.8)	33 (89.2)	
NS-RVO	14	5 (35.7)	9 (64.3)	
Hypertension	No	Hypertensive	Normotensive	p Value
		No (%)	No (%)	
AV-RVO	408	259 (63.5)	149 (36.5)	0.0558
OC-RVO	58	33 (56.9)	25 (43.1)	
NONHS-RVO	229	127 (55.5)	102 (44.5)	
ONHS-RVO	155	81 (52.3)	74 (47.7)	
NS-RVO	21	17 (81.0)	4 (19.0)	

The prevalence of primary open angle glaucoma (POAG), male sex, laterality, fellow eye involvement, smoking, and hypertension in the five subgroups of retinal venous occlusion (RVO) classified according to the site of occlusion. The proportions were compared among four subgroups (NS-RVO excluded) using the χ^2 test. No = number of cases; AV-RVO, arteriovenous crossing RVO; OC-RVO, optic cup RVO; NONHS-RVO, optic nerve sited RVO without ONHS; ONHS-RVO, optic nerve sited RVO with ONHS; NS-RVO, "No site" RVO.

ONHS-RVO (52.3%) or NONHS-RVO (55.5%), but not in comparison with the OC-RVO (56.9%) group. In the NS-RVO group, the prevalence of hypertension was 81.0%.

DISCUSSION

The results of this study indicate that classifying RVO by site of occlusion and ONHS separates them into groups that differ significantly in terms of both ocular and systemic variables. The diagnostic process, associated variables, and possible clinical relevance will be discussed below for each particular site.

Arteriovenous crossing RVO Diagnosis

Arteriovenous crossing RVO was the most common type, accounting for close to one half of our cases. They were readily diagnosed, reflecting the visibility of AV crossings and their usual occurrence well away from the optic disc, where other sites of occlusion are clustered. Eighteen cases of idiopathic parafoveal telangiectasis were referred to our centre with a diagnosis of RVO but were excluded by our definition of RVO. The process of identifying the exact site of occlusion and confirming that the pathology is in the distribution of the obstructed vein prevents this condition from being misdiagnosed as a RVO.

Figure 5 Confidence intervals (CI) for the differences in the prevalence of (A) primary open angle glaucoma (POAG), (B) smoking, (C) male sex, and (D) hypertension. The CIs were calculated at significance level of $p < 0.05$ for all parameters except POAG, which was calculated at $p < 0.0083$. The means of the compared groups were considered to differ significantly if the CI for the differences in means did not include zero (solid circles). AV, arteriovenous crossing RVO; OC, optic cup RVO; NONHS, optic nerve sited RVO without ONHS; ONHS, optic nerve sited RVO with ONHS; NS, "No site" RVO.

Associated variables

Thickened arteriolar walls have been shown to compress and narrow the venous lumen at AV crossings, setting the stage for an occlusion.²¹ Factors that selectively cause arteriolar wall pathology would be expected to be more closely associated with an AV-RVO. This was confirmed in our study by the significantly closer association of hypertension and smoking with this site of occlusion as opposed to other sites. Appiah and Trempe found hypertension to be more closely associated with a branch as opposed to a central, or hemicentral, RVO.⁹ Branch RVOs are in the vast majority of instances AV-RVOs, and this makes the findings in Appiah and Trempe's study very similar to our own. Smoking has not been shown to be selectively associated with a particular site of occlusion in the literature. We acknowledge that the data collection for smoking varied during the study. The errors associated with the variable collection of the data on smoking in this study should have affected each site equally.

Clinical significance

The closer association of hypertension and smoking with this site of occlusion emphasises the particular need to investigate vascular risk factors in patients who present with AV-RVO. The ocular pressure level and the incidence of glaucoma in AV-RVO were comparable to that found in the normal population.²² This conflicts with the findings from other large series.^{5,6}

Optic cup RVO

Diagnosis

Optic cup sited RVOs usually involve the papillary vein. It was difficult in some cases to distinguish an OC-RVO from optic nerve sited RVO without ONHS, because haemorrhage, oedema, blood vessels, or an undermined optic cup rim obscured the exact site of occlusion. In these cases, the appearance of the papillary vein as it crosses the floor of the optic cup is valuable in making the diagnosis. A narrowed papillary vein indicates an optic cup sited occlusion, while a dilated papillary vein suggests that the occlusion is within the optic nerve. This point is demonstrated in Figure 6, which shows the calibre difference between the occluded and fellow papillary veins in OC-RVO.

Occasionally, both the superior and inferior papillary veins can be occluded in the optic cup and be mistaken for a CRVO.

Once again, a narrowed, as opposed to dilated, papillary vein provides the diagnostic confirmation. A branch of the papillary vein is sometimes occluded in the optic cup causing sectoral pathology suggestive of an AV-RVO.

Associated variables

The close association of POAG and high ocular pressures with an occlusion occurring at an optic cup site is predictable. Forty per cent of patients presenting with an OC-RVO had POAG. The association with high ocular pressures, particularly after mydriasis, has been reported for occlusion in the optic cup.²³ The significantly older mean age in OC-RVO versus the other types of RVO is consistent with its association with POAG, whose incidence increases markedly with old age.²⁴

Figure 6 Digitally scanned colour fundus photographs showing an optic cup papillary vein occlusion. The proximal part of the occluded papillary vein is significantly thinner than the non-occluded trunk, and the site of abrupt venous calibre change can be traced to the rim of the optic cup (arrow).

Figure 7 Digital composite colour fundus photograph of an optic nerve sited central retinal vein occlusion without optic nerve head swelling, and a stereo pair of the optic nerve.

Clinical significance

Hayreh does not recognise the fact that a vein occlusion can occur at the optic cup as a distinct entity.² This study proves statistically that the diagnosis of OC-RVO can be made and is clinically useful. Lindholm studied the occurrence of RVO in patients with POAG and noted that occlusions occurring on the optic disc were located at the disc margin almost without exception.²⁵ He also made the observation that, in patients without glaucoma, the occlusion usually occurred at an AV crossing. He further confirmed the lack of association between AV crossing site of occlusion and POAG over a 10 year follow up. Dobree in 1957 was the first to describe the mechanisms for obstruction of a vein in a glaucomatous optic cup.²⁶ He suggested that an extensive cauldron-shaped excavation could lead to a considerable stretching and weakening of the walls of the vein, and that the vein walls, which have lost the support and protection of the optic nerve tissue, become directly exposed to the IOP. He pointed out that the effect must be most marked where the venous pressure is lowest. This can be confirmed by watching the venous pulsation, where the vein wall is seen to collapse at the edge of the rim or just inside the optic cup.

The occurrence of an OC-RVO in our opinion indicates a need to thoroughly assess ocular pressures with regard to preventing an occlusion in the fellow eye. This is of critical importance because papillary vein occlusions frequently cause severe loss of vision.

Optic nerve sited RVO without ONHS

Diagnosis

This group was the second most common type, accounting for around one quarter of our cases. The delineating features are the vein entering the disc as a dilated vein, and the absence of ONHS (Fig 7). The absence of ONHS has been proposed to

Figure 8 Digital composite colour fundus photograph of an optic nerve sited central retinal vein occlusion with optic nerve head swelling, and a stereo pair of the optic nerve. Note that the optic nerve head is swollen, such that the disc tissue is elevated above the peripapillary retina.

indicate that the site of occlusion is located at the lamina cribrosa (LC).¹⁵

Approximately two thirds of the NONHS-RVO group involved the CRV and one third involved the papillary vein, giving a ratio of 2 to 1. This suggests that a papillary vein passing through the LC has statistically the same risk of being occluded as a CRV. The papillary veins pass through the LC and join within the optic nerve to form the CRV in one fifth of the cases. In a random sample of, for example, five eyes, the expected number of CRV and papillary veins entering the LC would be four central and two papillary veins, giving the same 2 to 1 ratio. The diagnosis of an optic nerve sited papillary vein occlusion can only be made if the two papillary veins join behind rather than in front of the LC, as a congenital anatomical variation that occurs in 20% of eyes.¹⁷ It can be difficult to delineate optic nerve sited papillary vein occlusions without ONHS from optic cup sited papillary vein occlusions. The distinction may even be impossible if the papillary vein is obscured. The dilated, as opposed to narrowed, appearance of the papillary vein on the base of the optic cup confirms that the site of occlusion is in the optic nerve. The relative obstruction of a papillary vein can be confirmed by applying pressure to the globe and noting the early occurrence of venous pulsation in the fellow uninvolved papillary vein.

Occasionally, oedema and haemorrhage extend from the peripapillary retina onto the optic disc and mimic ONHS. This is particularly problematic for a disc that is naturally relatively prominent or elevated, such as a "disc at risk." It is important to evaluate the fellow eye for the presence of a similar elevated "disc at risk" appearance, which would assist in deciding whether the disc in the involved eye was swollen or naturally elevated.

Figure 9 Digital composite colour fundus photograph (left) and fluorescein angiogram (right) of a "no site" RVO involving a minor retinal vein. Its resembles an arteriovenous (AV) crossing RVO except for the site of occlusion, which is not associated with an AV crossing. There are multiple foci of venous staining in the non-occluded veins and the occluded vein shows prominent sheathing distal to the obstruction.

Associated variables

Nearly one in five patients with a NONHS-RVO had POAG; statistically significantly more than in AV-RVO or ONHS-RVO, and significantly less than in OC-RVO. This pattern of association was repeated for IOP.

Clinical significance

The association of raised IOP and POAG with NONHS-RVO is consistent with both these factors being associated with a posterior bowing of the LC, and LC being the site of occlusion of this type of RVO. Such bowing has been shown to cause disjunction of the trabeculae that form the LC.²⁷ The misalignment of the holes narrows and kinks the passageway through the LC.

Optic nerve sited RVO without ONHS and optic cup venous occlusions are anatomically very close and share two important clinical features: their relation to IOP and POAG, and the relative lack of available collateral channels with its resultant increased risk of retinal ischaemia. The similarity in their therapeutic aim in lowering ocular pressures makes a misdiagnosis between the two sites of little clinical consequence.

Optic nerve sited RVO with ONHS

Diagnosis

The diagnosis of this type of RVO was defined in this study by the presence of ONHS (Fig 8). Presence of minimal ONHS can cause variability in diagnosis, since the identification of ONHS is based on interpretation of stereo photographs as to whether the optic disc was swollen above the surrounding retina or not.

Optic nerve head swelling may be found in many diseases, including raised intracranial pressure, ocular hypotony, malignant hypertension, anterior ischaemic optic neuropathy and optic neuritis. In each instance the swelling has been shown to be due to a focal accumulation of axonal organelles and membranous debris as a result of a blockage of axonal transport at or immediately behind the LC.²⁸ Optic nerve head swelling in RVO indicates that the venous occlusion must have caused sufficient ischaemia immediately behind the LC to block axoplasmic transport. It must also cause sufficient retinal ischaemia to produce retinopathy in order to meet the definition of a RVO used in this study.

The ratio of central to papillary vein occlusion in ONHS-RVO group was 6 to 1. On the basis of the number of central retinal to papillary veins that enter the LC as separate vessels, the ratio should be 2 to 1, as was found in NONHS-RVO group. It may be, in some cases, that occluding only half of the venous drainage behind the LC does not cause enough ischaemia to block axoplasmic transport and lead to ONHS.

Associated variables

Optic nerve sited RVO with ONHS occurs in a significantly younger age group, with a mean age of 58 years compared to 64–69 years at other sites. They are less hypertensive than patients with an AV-RVO, but share with this group, normal IOP and a relatively low incidence of POAG.

Clinical significance

The younger age and tendency for lower prevalence of hypertension and POAG suggest that there may be other factors involved in the pathogenesis of RVO associated with ONHS. A type of CRVO characterised by mild retinopathy, prominent ONHS, and relatively young age of onset was first described by Lyle and Wybar.²⁹ Several names have been introduced for this entity, including "retinal vasculitis"²⁹ and "optic disc vasculitis,"³⁰ but it is best known as "papillophlebitis."³¹ The terminology suggests inflammation of the optic nerve head or the vein in the optic nerve, but conclusive evidence for this has not been found.

No site RVO

Diagnosis

This was the least common type of RVO and the most frequently misdiagnosed. There is a very strong tendency, based on the sectoral distribution of retinopathy, to automatically presume that the site of occlusion is at an AV crossing. Our study highlights the need to specifically examine each case for signs such as venous dilatation to confirm the exact site of occlusion. Figure 9 illustrates a case of presumed tuberculous phlebitis. The sectoral involvement would suggest that it is an AV-RVO, but on close examination, the change in vein calibre, the commencement of vein wall stain and distribution of pathology indicate that the site is distant from the nearest AV crossing. This figure also illustrates vascular sheathing, lipid exudation, and intense vein wall fluorescein staining that we have noted in many but not all of the NS-RVO in this series. These signs, when present, should emphasise the need to carefully evaluate the site of occlusion.

Associated variables

The small number of eyes with NS-RVO precluded a statistical evaluation of the variables studied. There were interesting trends such as a high rate of fellow eye involvement (third of the cases), a female predominance (62%), and a high prevalence of smoking (36%).

Clinical significance

In NS-RVO there is no external structure causing a narrowing of the lumen. This leaves the vein wall as the nidus for the occlusion. It is our opinion that NS-RVO, even if not associated

Figure 10 Digital composite colour fundus photographs and fluorescein angiographs of a case of hereditary idiopathic venous beading. The patient presented with a superonasal minor retinal vein occlusion and subsequently developed an inferotemporal main retinal vein occlusion. Note that the sites of occlusion do not correspond to an arteriovenous crossing (arrows). The patient was legally blind in the fellow eye with evidence of old retinal venous occlusion.

with gross sheathing, exudation, and angiographic leak, should be investigated for the causes of retinal phlebitis. In our 21 cases, this led to the diagnosis of two patients with active tuberculosis; two had blood pathology consistent with a mixed collagen disease and one each had AIDS, Behçet's disease and sarcoidosis. One case (Fig 10) had hereditary idiopathic venous beading, a primary vein wall disease.

CONCLUSION

This study has shown that the classification of RVO by the site of occlusion is important. This classification relates to one of the three causal factors in Virchow's triad—the vessel wall factor—that determine the occlusion of a vein. The precise anatomical location of the site of occlusion determines which factors, such as artery wall disease and IOP, have significant effects on the vein wall at that site. The conventional classification based on the anatomical vein and distribution can lead to erroneous grouping of aetiologically distinct types of RVO, and may add noise and confusion to the clinical picture. Classification based on the site of occlusion eliminates the terminological confusion associated with the standard branch and central RVO classification, helps to reduce misdiagnosis, and creates a logical framework on which to base investigation of the specific causal factors, and plan future studies of other risk factors.

Authors' affiliations

P E Beaumont, Eye and Vision Research Institute, Sydney, Australia
H K Kang, Department of Ophthalmology, Prince of Wales Hospital, Sydney, Australia

REFERENCES

- 1 **Clemett RS**, Kohner EM, Hamilton AM. The visual prognosis in retinal branch vein occlusion. *Trans Ophthalmol Soc UK* 1973;**93**:523–35.
- 2 **Hayreh SS**, Hayreh MS. Hemi-central retinal vein occlusion. Pathogenesis, clinical features, and natural history. *Arch Ophthalmol* 1980;**98**:1600–9.
- 3 **Gomez-Ulla de Irazazabal FJ**, Cadarso Suarez L, Orduna Domingo E. Hemispheric retinal branch vein occlusions. *Ophthalmologica* 1986;**193**:14–22.
- 4 **Sanborn GE**, Magargal LE. Characteristics of the hemispheric retinal vein occlusion. *Ophthalmology* 1984;**91**:1616–26.
- 5 **Sperduto RD**, Hiller R, Chew E, et al. Risk factors for hemiretinal vein occlusion: comparison with risk factors for central and branch retinal vein occlusion: the eye disease case-control study. *Ophthalmology* 1998;**105**:765–71.

- 6 **The Eye Disease Case-control Study Group**. Risk factors for branch retinal vein occlusion. *Am J Ophthalmol* 1993;**116**:286–96.
- 7 **The Eye Disease Case-control Study Group**. Risk factors for central retinal vein occlusion. *Arch Ophthalmol* 1996;**114**:545–54.
- 8 **Appiah AP**, Trempe CL. Risk factors associated with branch vs central retinal vein occlusion. *Ann Ophthalmol* 1989;**21**:153–5, 157.
- 9 **Appiah AP**, Trempe CL. Differences in contributory factors among hemicentral, central, and branch retinal vein occlusions. *Ophthalmology* 1989;**96**:364–6.
- 10 **Rath EZ**, Frank RN, Shin DH, et al. Risk factors for retinal vein occlusions. A case-control study. *Ophthalmology* 1992;**99**:509–14.
- 11 **Soni KG**, Woodhouse DF. Retinal vascular occlusion as a presenting feature of glaucoma simplex. *Br J Ophthalmol* 1971;**55**:192–5.
- 12 **Frucht J**, Shapiro A, Merin S. Intraocular pressure in retinal vein occlusion. *Br J Ophthalmol* 1984;**68**:26–8.
- 13 **Luntz MH**, Schenker HI. Retinal vascular accidents in glaucoma and ocular hypertension. *Surv Ophthalmol* 1980;**25**:163–7.
- 14 **Johnston RL**, Brucker AJ, Steinmann W, et al. Risk factors of branch retinal vein occlusion. *Arch Ophthalmol* 1985;**103**:1831–2.
- 15 **Beaumont PE**, Kang HK. Pattern of vascular nonperfusion in retinal venous occlusions occurring within the optic nerve with and without optic nerve head swelling. *Arch Ophthalmol* 2000;**118**:1357–63.
- 16 **Duke-Elder S**, Wybar KC. *The anatomy of the visual system*. St Louis: CV Mosby, 1961.
- 17 **Chopdar A**. Dual trunk central retinal vein incidence in clinical practice. *Arch Ophthalmol* 1984;**102**:85–7.
- 18 **Clemett RS**. Retinal branch vein occlusion. Changes at the site of obstruction. *Br J Ophthalmol* 1974;**58**:548–54.
- 19 **Scheffe H**. *The analysis of variance*. New York: John Wiley, 1959:75–83.
- 20 **Brown RA**, Swanson-Beck J. *Medical statistics on personal computers*. 2nd ed. London: BMJ Publishing Group, 1994.
- 21 **Ennema MC**, Zeeman WP. Venous occlusions in the retina. *Ophthalmologica* 1953;**126**:329–47.
- 22 **Colton T**, Ederer F. The distribution of intraocular pressures in the general population. *Surv Ophthalmol* 1980;**25**:123–9.
- 23 **Beaumont P**, Goldberg I, Hollows FC. Optic cup vein occlusion; description of a new entity. *Trans Ophthalmol Soc NZ* 1976;**28**:115–17.
- 24 **Hart Jr. WM**. The epidemiology of primary open-angle glaucoma and ocular hypertension. In: Ritch R, Shields MB, Krupin T, eds. *The glaucomas*. St Louis: CV Mosby, 1989:789–95.
- 25 **Lindblom B**. Open angle glaucoma and non-central retinal vein occlusion—the chicken or the egg? *Acta Ophthalmol Scand* 1998;**76**:329–33.
- 26 **Dobree JH**. Venous obstruction and neovascularization at the disc in chronic glaucoma. *Trans Ophthalmol Soc UK* 1957;**77**:229–38.
- 27 **Emery JM**, Landis D, Paton D, et al. The lamina cribrosa in normal and glaucomatous human eyes. *Trans Am Acad Ophthalmol Otolaryngol* 1974;**78**:290–7.
- 28 **Garner A**. *Vascular diseases*. 2nd ed. New York: Marcel Dekker, 1994.
- 29 **Lyle TK**, Wybar K. Retinal vasculitis. *Br J Ophthalmol* 1961;**45**:778–88.
- 30 **Hayreh SS**. Optic disc vasculitis. *Br J Ophthalmol* 1972;**56**:652–70.
- 31 **Lonn LI**, Hoyt WF. A cause of protracted yet benign optic disc oedema. *The Eye, Ear, Nose and Throat Monthly* 1966;**45**:62–8.