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## Colour Doppler imaging before and after retrobulbar anaesthesia in patients undergoing cataract surgery

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**Abstract Purpose:** To investigate the effect of retrobulbar anaesthesia on retrobulbar haemodynamics, colour Doppler imaging was performed. Furthermore, the additive effect of epinephrine was examined.

**Method:** Forty-one patients (age  $72.7 \pm 8.9$ ; 22 f, 19 m) undergoing planned cataract surgery were included in a prospective study. Colour Doppler imaging was performed before and directly after retrobulbar anaesthesia and after cataract surgery to measure the peak systolic velocity (PSV) and end-diastolic velocity (EDV) in the ophthalmic artery, central retinal artery and central retinal vein. In 18 patients lidocaine 2% without additives (2 ml, retrobulbar transconjunctival injection) and in 23 patients lidocaine 2% with epineph-

rine 1:200,000 was used. **Results:** After retrobulbar anaesthesia both groups had a significant reduction of the PSV and of the EDV. After surgery flow velocities increased again. The addition of epinephrine resulted in a significantly greater reduction and slower recovery of flow velocities. **Conclusion:** Retrobulbar anaesthesia induces a marked reduction of velocity in the retrobulbar vessels. The supplement epinephrine increases this effect, and recovery is much slower. Thus, particularly in patients with already disturbed ocular haemodynamics epinephrine should not be used in order to avoid irreversible functional damage.

### Introduction

Different types of anaesthesia techniques for cataract surgery are common. In the eighties retrobulbar anaesthesia was, at 85%, the most common form used for anaesthesia [14]. Although drop anaesthesia is becoming more and more attractive, retrobulbar anaesthesia is still employed in patients with high motility of the eye and in cases expected to be difficult. Different local anaesthetic drugs and different drug supplements like epinephrine are used. The vasoconstrictive effect of epinephrine is utilised in retrobulbar anaesthesia to slow absorption of the anaesthetic in general circulation and thus to achieve a longer effect in the orbit. However, the effect of different local anaesthetic procedures, local anaesthetics and drug supplements on ocular blood flow is not clear.

Complications beside penetration of the needle in the globe following local anaesthesia are ischaemic optic neuropathy [1, 7, 20] occlusion of the central retinal artery [12] and retinal [4] or outer retinal ischaemic infarction [19]. This implies that there is a vascular change after local anaesthesia and the complication risk differs by local anaesthetic technique and drug supplement, and vascular risk factors of the patients.

Previous studies with different techniques assessed the influence of retrobulbar anaesthesia. The pulsatile ocular blood flow decreased markedly after retrobulbar anaesthesia with and without epinephrine [11]. The recovery of the pulsatile ocular blood flow after retrobulbar anaesthesia was very slow [2]. Recent examinations by colour Doppler imaging (CDI) in monkeys showed that retrobulbar anaesthesia with lidocaine and epinephrine significantly reduced

**Table 1** Clinical and demographic data of all patients

	Retrobulbar anaesthesia with epinephrine	Retrobulbar anaesthesia without epinephrine	<i>p</i> Value
Numbers	23	18	
Age (years)	71±8	75±5	0.21
Sex (male;female)	14; 9	5; 13	0.06
Systolic blood pressure before operation (mmHg)	174±27	165±23	0.24
Diastolic blood pressure before operation (mmHg)	87±11	84±14	0.37
Mean arterial pressure before operation (mmHg)	122±16	113±14	0.05
Pulse before operation	73±11	75±17	0.71
Visual acuity in log MAR	0.81±0.68	0.70±0.65	0.58
Corresponding metric value	0.16	0.20	
Intraocular pressure (mmHg)	16.3±3.9	17.7±7.4	0.42
Axial length (mm)	23.29±1.17	23.24±1.09	0.89

the retrobulbar haemodynamics in the central retinal artery and the posterior ciliary arteries [18].

CDI is a non-invasive ultrasound technique that combines B-scan grey-scale imaging of the tissue structure, coloured representation of blood flow based on Doppler-shifted frequencies and pulsed-Doppler measurement of blood flow velocities. CDI can give data on flow velocities of retrobulbar blood vessels and vascular downstream resistance. A variety of occlusion diseases of the eye and the orbit have been examined by CDI. CDI is also used in a wide range of other diseases of the eye in which vascular aetiology has been implicated, e.g. glaucoma [3, 6, 15, 23].

In this study CDI was performed to quantify the effect of retrobulbar anaesthesia on retrobulbar haemodynamics. Furthermore, the additive effect of the drug supplement epinephrine was examined.

## Material and methods

### Patients

In this prospective study 41 patients scheduled for cataract surgery (small incision, phako with IOL implanta-

tion) were recruited. Eyes with a refractive error greater than 4 dioptres and eyes with an axial length less than 21 mm or more than 25.5 mm were excluded. Exclusion criteria were the presence of systemic diseases affecting ocular circulation, e.g. arterial hypertension or diabetes mellitus. Furthermore, patients with vascular occlusion in the studied or in the second eye were excluded. The patients with systemic intake of vaso-active medication, e.g. aspirin, were also excluded.

Twenty-three of the patients (age 71±8 years; 14 men, 9 women) underwent retrobulbar anaesthesia with 2 ml lidocaine (Xylocaine) 2% and epinephrine (1:200,000). The other 18 patients (age 75±9 years; 5 men, 13 women), selected randomly, had retrobulbar anaesthesia with 2 ml lidocaine 2% without epinephrine supplement. For safety reasons the surgeon was not blinded to the content of the retrobulbar injection. The data of both groups are shown in Table 1.

Informed consent was obtained from each subject including detailed explanation of all procedures before participation in the study. The study adhered to the tenets of the Helsinki declaration.

### Method

Measurements of retrobulbar velocity were performed using a CDI device (Sonoline Sienna; Siemens, Germany) in a standardised manner [5]. The scan was performed with the patient in supine position with eyes closed and directed to gaze towards the ceiling. A 7.5-MHz linear phased-array transducer was applied with contact jelly on the upper eyelid while the examiner's hand rested upon the orbital margin to minimise the pressure on the globe. All examinations were performed by one experienced examiner (K. K.H.). A 0.2 mm by 0.2 mm Doppler sample window was

**Table 2** Means and standard deviations of flow velocities (cm/s) assessed by colour Doppler imaging in patients undergoing cataract surgery with retrobulbar anaesthesia and epinephrine supplement

Parameter	Before operation (baseline)	After retrobulbar anaesthesia	After surgery
OA PSV	31.83±7.41	18.09±5.27*	24.51±6.37 <sup>+</sup>
OA EDV	6.36±2.28	3.84±1.59*	6.2±2.52 <sup>+</sup>
OA RI	0.80±0.05	0.79±0.05	0.75±0.06
CRA PSV	11.61±1.34	7.36±1.74*	9.31±1.64 <sup>+</sup>
CRA EDV	3.00±0.82	2.14±0.59*	2.50±0.56 <sup>+</sup>
CRA RI	0.74±0.06	0.71±0.06	0.73±0.06
CRV PSV	4.95±0.95	3.34±1.06*	4.04±1.05 <sup>+</sup>
CRV EDV	2.74±0.72	1.94±0.65*	2.27±0.64 <sup>+</sup>

\**p*<0.001 vs baseline; <sup>+</sup>*p*<0.001 vs after anaesthesia.

**Table 3** Means and standard deviations of flow velocities (cm/s) assessed by colour Doppler imaging in patients undergoing cataract surgery with retrobulbar anaesthesia and no epinephrine supplement

	Before operation	After retrobulbar anaesthesia	After surgery
OA PSV	30.41±7.24	23.24±7.18*	27.58±6.5 <sup>+</sup>
OA EDV	5.97±1.98	5.17±2.38*	6.46±2.74 <sup>+</sup>
OA RI	0.80±0.05	0.78±0.08	0.77±0.07
CRA PSV	11.21±1.84	9.49±1.88*	10.7±1.94 <sup>+</sup>
CRA EDV	2.91±0.61	2.38±0.53*	3.00±0.64 <sup>+</sup>
CRA RI	0.74±0.07	0.74±0.05	0.72±0.06
CRV PSV	4.76±0.84	3.49±0.76*	4.18±0.74 <sup>+</sup>
CRV EDV	2.39±0.58	1.84±0.40*	2.38±0.38 <sup>+</sup>

\* $p < 0.001$  vs baseline; <sup>+</sup> $p < 0.001$  vs after anaesthesia.

used to perform the measurements of the ophthalmic artery, the central retinal artery and the central retinal vein. Peak systolic velocities (PSV) and end-diastolic velocities (EDV) were obtained from the velocity waveforms of each artery. The resistive index (RI) known as Pourcelot's

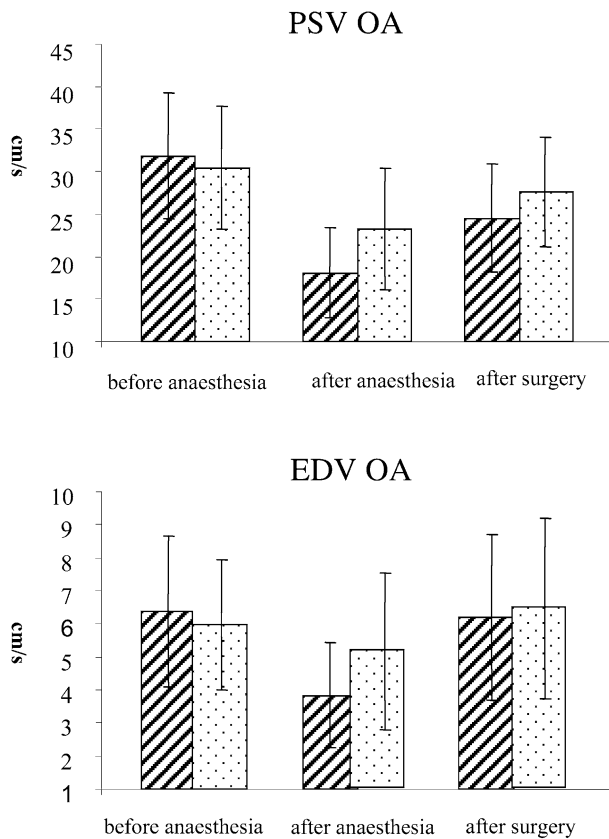
ratio was measured. This parameter of downstream resistance was calculated by the formula  $(PSV - EDV) / (PSV)$  to characterise peripheral vascular resistive of the vessels studied [5].

In this study CDI was carried out before and directly after retrobulbar anaesthesia and after completion of cataract surgery. Furthermore, the cardiovascular parameters systolic and diastolic blood pressure and pulse were measured simultaneously. Cataract surgery was performed by one surgeon (A.R.) with a close-to-cornea 2.8-mm incision and phakoemulsification with implantation of a hydrophobic foldable intraocular lens (Acrysof; Alcon, Fort Worth, USA).

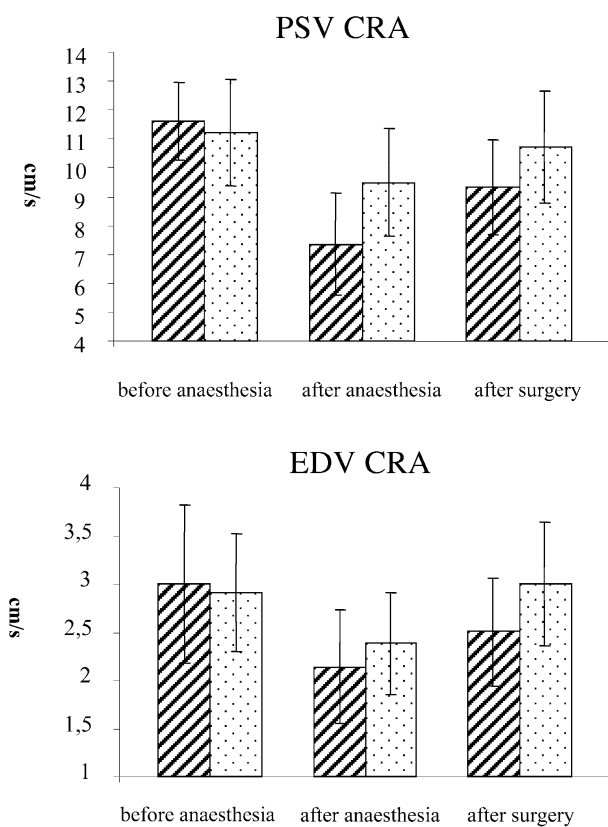
#### Statistical analysis

The statistical analysis was performed using analysis of variance (ANOVA) as computed with Statview (SAS Institute, Cary, NC, USA). A repeated-measures ANOVA was used for testing the interaction of added supplements.

For post hoc testing, calculations with Fisher's protected least significant difference were carried out. Findings of probability of a type error less than 0.05 were considered to



**Fig. 1** Peak systolic velocity (PSV) and end-diastolic velocity (EDV) of the ophthalmic artery (OA) after retrobulbar anaesthesia with epinephrine (hatched column) and without epinephrine (dotted column)



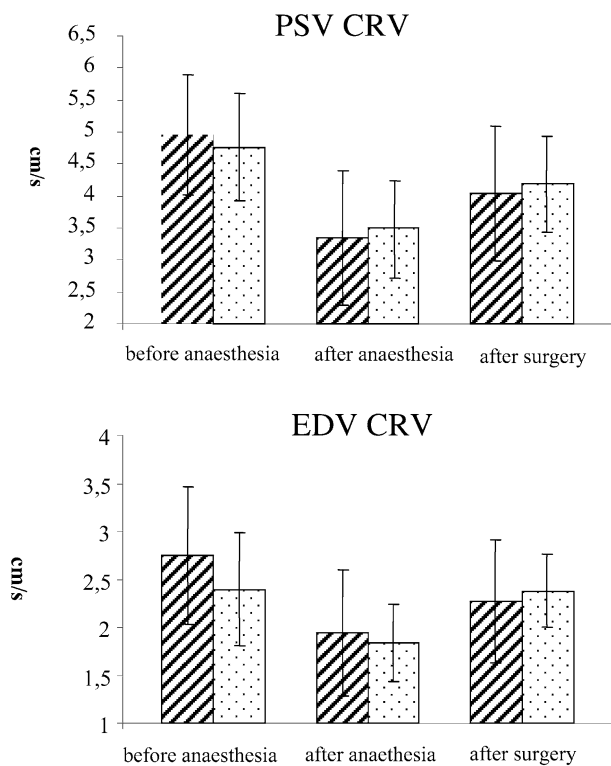
**Fig. 2** Peak systolic velocity (PSV) and end-diastolic velocity (EDV) of the central retina artery (CRA) after retrobulbar anaesthesia with epinephrine (hatched column) and without epinephrine (dotted column)

be statistically significant. For the comparison of discrete variables, a Chi-square test was calculated for each contingency table.

## Results

After retrobulbar anaesthesia both groups had a significant reduction in PSV and EDV for all measured vessels. For the ophthalmic artery the PSV decreased by 34% and the EDV by 27%. In the central retinal artery the PSV decreased by 26% and the EDV by 23%. In the central retinal vein there was a reduction of the PSV by 30% and of the EDV by 26%. After surgery, flow velocities increased again. In the ophthalmic artery the PSV increased by 26% and the EDV by 40%. In the central retinal artery the velocities increased by 19% for the PSV and by 22% for the EDV ( $p<0.0001$ ). The PSV of the central retinal vein increased by 20% and the EDV by 23%. The RI in all vessels remained unchanged after retrobulbar anaesthesia and after surgery for both groups. Furthermore, axial length had no influence on retrobulbar haemodynamics.

Subgroup analysis revealed that the eyes treated with epinephrine had a significantly greater reduction in velocity after retrobulbar anaesthesia. Exact means and standard



**Fig. 3** Peak systolic velocity (PSV) and end-diastolic velocity (EDV) of the central retina vein (CRV) after retrobulbar anaesthesia with epinephrine (hatched column) and without epinephrine (dotted column)

**Table 4** Means and standard deviations of blood pressure (mmHg) and heart rate (beats/min) in patients undergoing cataract surgery with retrobulbar anaesthesia and epinephrine supplement

	Before operation	After retrobulbar anaesthesia	After operation
Systolic blood pressure	175±27	169±27	162±23*
Diastolic blood pressure	87±11	86±15	84±11*
Mean arterial pressure	123±16	123±25	117±15*
Heart rate	73±11	74±12	71±17*

\* $p<0.05$  to baseline.

**Table 5** Means and standard deviations of blood pressure (mmHg) and heart rate (beats/min) in patients undergoing cataract surgery with retrobulbar anaesthesia and no epinephrine supplement

	Before operation	After retrobulbar anaesthesia	After operation
Systolic blood pressure	165±23	162±23	161±26*
Diastolic blood pressure	84±14	83±12	79±16*
Mean arterial pressure	113±14	116±18	108±17*
Heart rate	75±17	72±17	69±12*

\* $p<0.05$  to baseline.

deviations of the velocities as shown by CDI (cm/s) are presented in Table 2.

ANOVA statistics (Tables 2, 3) showed that the addition of epinephrine resulted in significantly greater reductions and slower recovery of the PSV in the ophthalmic artery ( $p<0.0004$ ) and central retinal artery ( $p<0.0001$ ). Furthermore, the EDV of the ophthalmic artery ( $p=0.0014$ ), the central retinal artery ( $p=0.0335$ ) and the central retinal vein ( $p<0.0355$ ) decreased more and recovered more slowly in the group with added epinephrine (Figs. 1, 2, 3).

Cardiovascular parameters in both groups were significantly different before and after surgery with regard to the systolic ( $p<0.005$ ) and diastolic ( $p<0.0177$ ) blood pressures. The mean arterial blood pressure ( $p<0.0404$ ) and the heart rate ( $p<0.0154$ ) also differed significantly before and after surgery (Tables 4, 5). The patients treated with epinephrine supplement showed no difference in cardiovascular parameters from those without epinephrine.

## Discussion

In this study we found a reduction in retrobulbar blood flow velocities after retrobulbar anaesthesia. The velocities re-

covered only slowly and were still below baseline after surgery. These findings confirm previous reports on the influence of retrobulbar anaesthesia on ocular blood flow. Hulbert et al. [11] found a marked decrease in the pulsatile ocular blood flow after retrobulbar anaesthesia with and without epinephrine.

Several factors may account for the dramatic reduction in blood flow velocity after retrobulbar anaesthesia. First, there is mechanical compression of the retrobulbar tissue space, as a volume effect. This may initiate the decrease in retinal perfusion. Previously, reductions in the systolic retinal and ciliary perfusion pressures were found after an injection of 5 ml but not after an injection of 2 ml [9]. In this study we found a reduction in retrobulbar velocity after an injection volume of 2 ml.

Second, it is known, that retrobulbar anaesthesia induces a rise in the intraocular pressure (IOP) of 3–4 mmHg [9, 16]. The effect of the IOP increase after retrobulbar anaesthesia is only short term [9]. Hessemer et al. [9] showed that the retinal and ciliary perfusion pressures remained decreased after the IOP had already returned to baseline.

Third, the autoregulation of the retinal circulation may be affected by local anaesthesia. Meyer et al. [17] demonstrated that bradykinin is prevented from relaxing porcine ciliary arteries in the presence of amide-type anaesthetic agents such as lidocaine. This may be an explanation for the sustained decrease in ocular blood flow. The diffusion of local anaesthetic into the retrobulbar vessels is proven by the detection of local anaesthetic agent in the peripheral blood [21].

In conclusion, the reduction in the retrobulbar velocity after retrobulbar anaesthesia was less marked, but still present, after surgery, when IOP had returned to baseline [9]. At that time the volume effect of the local anaesthetic on the retrobulbar haemodynamics has dissipated, because the agent has already spread into the surrounding tissue. This supports the theory of drug-induced vasoconstriction after retrobulbar anaesthesia.

Epinephrine is used in retrobulbar anaesthesia to slow the absorption of the anaesthetic, presumably by local vasoconstriction. Use of epinephrine in the retrobulbar solution may prolong the duration of anaesthesia [13]. On the other hand, epinephrine is known to have a vasoconstrictive effect [22]. In this study we showed a greater reduction and slower recovery of retrobulbar velocity after retrobulbar anaesthesia with the supplement of epinephrine. These results confirm those of other studies; greater reductions in ocular pulsation volume and in ciliary and retinal perfusion pressure are reported after retrobulbar anaesthesia with epinephrine [10]. Thus, there is a higher risk of reduced blood supply in the retina. Retrobulbar anaesthesia with epinephrine may therefore be associated with an increased risk of ischaemic complications [8].

In summary, there is a reduction in the retrobulbar velocity after retrobulbar anaesthesia; this may be due to a drug-induced vasoconstrictive effect of the local anaesthetics. This effect is enhanced by supplementation with epinephrine. Therefore, particularly in patients with already disturbed ocular haemodynamics retrobulbar anaesthesia with epinephrine should not be used in order to avoid irreversible functional damage.

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