Cataract surgery anaesthesia: is topical anaesthesia really better than retrobulbar?

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ABSTRACT.
Purpose: **To compare the effectiveness for the patient of retrobulbar anaesthesia (RBA) and topical anaesthesia (TA) in cataract surgery by phacoemulsification.**
Methods: **We performed a prospective, randomized study on 115 patients operated at our clinic using the two anaesthesia techniques. The RBA group comprised 57 patients (20 women, 37 men; age 72 ± 10 years); the TA group comprised 58 patients (20 women, 38 men; age 74 ± 10 years). Measured parameters were: blood pressure; heart rate; blood oxygen saturation level; serum adrenaline, noradrenaline and cortisol levels; white blood cell count; indicated pain during the procedure, and pain as reported by the patient afterwards. Two psychological tests were used: the State–Trait Anxiety Inventory (STAI), and the patient-selected face-scale test. Statistical analysis was performed using Student's *t*-test and the chi-square test. Results were also analysed using a logistic regression model.**
Results: **Both types of anaesthesia were adequate for the surgical procedure. In the RBA group fewer patients experienced pain during surgery ($p < 0.01$) and fewer recalled any perioperative discomfort. With RBA the objective parameters were more stable than with TA, and systolic blood pressure was significantly lower ($p = 0.01$). The logistic model was able to predict perioperative pain with 93% certainty. Pain sensitivity was higher in younger patients and in patients with higher initial cortisol and noradrenaline serum levels.**
Conclusions: **Both methods of anaesthesia are appropriate, but phacoemulsification with TA is more painful than with RBA. In hypertonic patients and younger patients who are more susceptible to pain, TA should be avoided or used in combination with individualized sedation.**

Key words: RBA (retrobulbar anaesthesia) – TA (topical anaesthesia) – phacoemulsification – pain – adrenocortical system – psychological tests

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Introduction

Since 1970, significant improvements in surgical techniques for cataract operations have been made following the introduction of phacoemulsification. As the techniques for cataract surgery have changed, so have requirements for anaesthesia. In theory, topical anaesthesia (TA) is sufficient when phacoemulsification is used. Accordingly, this method has come into general use since the first reports of experiences using topical anaesthesia were published (Kershner 1993; Patel et al. 1996).

However, as the data in the literature and our clinical experiences indicate, many patients experience pain in the perioperative period with TA (Friedman et al. 2001). In the present study we compared the effects of retrobulbar anaesthesia (RBA) with those of TA in our clinical practice.

We had three main objectives. The first was to analyse which method could provide better conditions for the patient and prevent the activation of the adrenocortical system in the perioperative period. The second involved analysing the results to determine those factors that change according to the type of anaesthesia, the level of pain and the psychological state of the patient. Thirdly, we aimed to analyse the results in order to identify those factors that increase the risk of patient discomfort or pain in the perioperative period, and to predict the most appropriate anaesthetic method for a given patient.

Materials and Methods

The study was performed at the Second Department of Ophthalmology, Semmelweis University, Budapest, with the permission of the University Ethics Committee (No. 136/2003).

A total of 115 patients who were awaiting cataract surgery (phacoemulsification and foldable posterior chamber lens implantation) were enrolled in a prospective, randomized, comparative study, running from June 1st to September 13th, 2004. The patients were informed of the study objectives and the examination processes and were asked for written consent. If the patient or surgeon did not agree with the planned anaesthetic method, the patient was excluded from the study.

We used strict ophthalmic and general exclusion criteria. Ophthalmic exclusion criteria were: the presence of any other ophthalmic disease apart from cataracts; previous surgery on the same eye, and increased risk of complications (e.g. problems with pupil dilatation).

General exclusion criteria were: tremor; chronic cough; psychiatric disturbances; deafness; uncontrolled diabetes or high blood pressure; any problem with lying on the back, and any allergy to local anaesthetics (MacPherson 2004). Diabetes and hypertonic patients whose conditions were not well controlled were excluded from this study.

The patients were randomized according to weekdays and divided into two groups. The RBA group included 57 patients (20 men, 37 women) with a mean age of 72 years (range 43–90 years, standard deviation [SD] ± 10 years). The TA group included 58 patients (20 men, 38 women) with a mean age of 74 years (range 47–90 years, SD ± 10 years).

All data were recorded on five different data sheets by different independent assistants, who were masked to previous measurements for the given patient.

Each patient was subject to the same preoperative protocol. On the day prior to surgery the patient received tobramycin and Na-diclofenacum drops five times and an assistant completed a State–Trait Anxiety Inventory (STAI) questionnaire and a face-scale test (see below).

The STAI test is a special questionnaire that enables calculation of the usual (STAI-trait) and actual (STAI-state) anxiety state of patients (Spielberger et al. 1970; Schaffer et al. 1988). It was adapted for use in Hungary in 1977 (Sipos & Sipos 1978). Normal levels are 42.5 for the STAI-trait and 35.7 for the STAI-state. The face-scale test consists of nine face pictures, from which the patient chooses the picture that best reflects his or her current mood.

On the morning of the day of the operation, patients received Na-cyclopentolate and phenylephrine 10% drops on two occasions, ate a light breakfast and took any regular medication that they were using. The patient's blood pressure was checked and blood samples were taken between 06.00 hours and 07.00 hours. About 1 hour before surgery, each patient received 0.25 mg alprazolanum orally. The patient went to the preparation room 30 mins before surgery and once again his or her blood pressure was measured. Patients were able to watch the progress of the preceding patient's operation on a video monitor screen.

Patients in the RBA group received a 3.5-ml anaesthetic mixture consisting of 1.75 ml lidocaine 2% (without adrenaline or preservatives) and 1.75 ml bupivacaine 0.5%, delivered via a 25-gauge sharp needle through the skin into the retrobulbar space from the temporal lower part of the orbit, for about 30 seconds. A soft pressure device was then placed on the eye for 20 mins. At the start of the operation, the patient received one drop of oxybuprocain solution (approximately 40 μg).

Those in the TA group received two drops of oxybuprocain (one into the inferior and one into the superior cul-de-sac) on three occasions: 10 mins and 5 mins before surgery, and at the start of the procedure.

The disinfection procedure was performed using a POVIDON iodine complex (Braun Medical AG, Emmenbrucke, Switzerland). A 3.2-mm clear cut knife was used to perform clear corneal incisions from the temporal or upper part of the cornea. The procedure involved a continuous curvilinear capsulorrhexis, hydrodissection, and phacoemulsification (using either a 'divide and conquer' or 'stop and chop' coaxial technique) with the ALCON Legacy phaco instrument (Alcon Laboratories, Inc., Fort Worth, TX, USA); this was followed by implantation of a foldable acrylic artificial lens. The wound was then closed by hydration. The infusion solution contained 1 mg adrenalin/500 ml. All the operations were performed in the morning.

During the operation, heart rate and blood pressures were checked every 5 mins. The pupil diameter was checked at the start of surgery, before the intraocular lens (IOL) implantation and at the end of the procedure, using a Castroviejo calliper. If the patient indicated any pain, the pupil diameter was measured again during the surgery.

We recorded any indicated pain or discomfort, the stages of the operation, any supplementary anaesthesia (oxybuprocain drops) required, the patient's movements, and any surgical complications that arose.

At the end of surgery, a further blood sample was taken to enable comparisons of cortisol, adrenaline and noradrenaline levels and white blood cell count with preoperative levels.

The duration of the whole procedure – from the time the patient was laid on the operating table and the assistant started the disinfection procedure, until the patient got up from the table with a patch on his or her operated eye – was on average 25 mins.

The phaco time and energy, the surgeon's name and his or her level of experience with such surgery (5–10 operations/week, or > 10 operations/week) were also recorded. Three experienced and four less experienced surgeons were involved in this study. (In our clinic, every surgeon has to perform his or her first 100 operations using RBA; thereafter, the surgeon can choose the methods of anaesthesia.)

On the same afternoon, an independent interviewer asked the patient for his or her opinion on the procedure, both in terms of the anaesthesia (drop or injection) and the operation itself. We used a four-level pain scale (none, slight, medium, extreme) (Ohnhaus & Adler 1975).

The following morning, a different interviewer repeated the STAI and face-scale tests. Visual acuity (VA) was recorded before and after surgery, using a Snellen chart.

In some cases, patients refused to give a blood sample or there were technical problems with the laboratory tests. During surgery, some asked for the blood pressure and O_2 saturation monitoring to be stopped. In a few cases, the patient left the clinic before the postoperative psychological tests were carried out. Others did not give permission for the data (VA, STAI and face-scale test) to be analysed. The numbers of these incidents are recorded in Tables 1–3.

Statistical methods used were as follows. Pairwise comparisons were performed using Student's *t*-test for independent samples. The two-level data (e.g. patient gender) were compared using the chi-square test.

We also analysed the effect of preoperative variables using a logistic regression model.

We introduced the variables into the model based on medical considerations, thereby creating a better model than we would have been able to achieve by statistical selection procedures.

The model also includes the interaction of the variables, thus enabling it to give a better fit to the data.

To make the results easier to interpret, the following variables were standardized: blood pressure and adrenaline, noradrenaline, cortisol levels measured from blood samples.

From our results, we also reported the goodness-of-fit. We set the base level within the classification table (dividing the two groups with an estimated probability of 0.5).

For statistical analysis, Statistica Version 6.0 was used (Statsoft Inc., Tulsa, OK, USA). A p-value (two-sided) < 0.05 was considered significant.

Results

Prior to surgery there were no significant differences between the groups in VA, results of blood tests, results of psychological tests, blood pressure, heart rate, O_2 saturation levels, or pupil diameter (Table 1). There were also no significant differences in the surgical environment, the time of operation, the surgeon's experience level (> 10 operations performed per week, or fewer than this), and the time and amount of energy used in the phacoemulsification (Table 2).

Differences emerged when we compared the data for the RBA and TA groups taken during and after the surgery, including the postoperative interviews (Table 3). We have summarized the results as follows.

In all cases, the anaesthesia was sufficient to perform the surgery. If the patient indicated pain, we used oxybuprocain eyedrops; after that, the anaesthesia was in each case adequate to continue the surgery. In each group there were two cases of posterior capsule rupture. In one case, anterior vitrectomy was necessary.

More patients in the TA group indicated pain during the procedure (RBA group: two cases; TA group: 15 cases). The differences increased when the patients were later asked (at

Table 1. Data before surgery. Pairwise comparisons, Student *t*-test for independent samples.

	RBA group			TA group			Difference		
Data	Valid N	Mean	SD ±	Valid N	Mean	SD ±	*t*-level	df	p
Age (years)	57	72	10	58	74	9.81	− 0.9	113	0.37
Visual acuity (Snellen chart)	55	0.28	0.21	52	0.33	0.21	− 1.0	105	0.31
White blood cell count (g/l)	44	7.47	2.49	49	6.70	2.24	1.6	91	0.12
Noradrenaline (nmol/l)	54	2.11	1.21	52	2.42	1.29	− 1.3	104	0.20
Adrenaline (nmol/l)	52	0.35	0.24	43	0.39	0.26	− 0.9	93	0.37
Cortisol (nmol/l)	55	488	158	58	483	151	0.2	111	0.85
Systolic blood pressure (mmHg)	55	140	17	56	140	16	0.0	109	0.98
Diastolic blood pressure (mmHg)	55	74	10	56	71	13	1.3	109	0.21
Heart rate/min	44	77	13	50	75	12	0.9	92	0.35
Blood O_2 saturation (%)	43	97	1.3	44	97	1.6	− 0.1	85	0.93
Pupil diameter (mm)	51	6.2	0.9	52	6.2	1.0	0.2	101	0.81
Face-scale test	55	3.6	1.6	58	3.3	1.5	0.9	111	0.36
State–Trait Anxiety Inventory: trait	55	49.9	5.1	58	49.7	4.6	0.1	111	0.90
State–Trait Anxiety Inventory: state	55	47.3	3.9	58	45.7	4.6	1.9	111	0.06
Gender	Pearson $\chi^2 < 0.01$; df = 1; p = 0.94								

RBA = retrobulbar anaesthesia; TA = topical anaesthesia; SD = standard deviation; df = degrees of freedom.

Table 2. Surgical data. Pairwise comparisons, Student's *t*-test for independent samples.

	RBA group			TA group			Difference		
Data before surgery	Valid N	Mean	SD ±	Valid N	Mean	SD ±	*t*-level	df	p
Ultrasound use (mins)	50	1.8	1.1	52	1.7	1.0	0.3	102	0.73
Ultrasound energy (%)	50	17.2	8.4	52	19.9	7.5	− 1.8	102	0.08
Duration of operation (mins)	57	26	5.5	57	26	6.2	− 0.4	112	0.69
Surgeon's experience*		Pearson $\chi^2 = 2.5$; df = 1; p = 0.11							

RBA = retrobulbar anaesthesia; TA = topical anaesthesia; SD = standard deviation; df = degrees of freedom.

* Five to 10 operations/week, or > 10.

Table 3. Comparative results in the two groups during and after surgery. Pairwise comparisons, Student's *t*-test for independent samples.

		RBA group			TA group			Difference		
Data	Time of measurement	Valid N	Mean	SD ±	Valid N	Mean	SD ±	*t*-level	df	p
VA (Snellen chart)	Day after surgery	54	0.61	0.29	53	0.59	0.26	0.4	105	0.72
White blood cell count (g/l)	End of surgery	44	6.57	1.64	43	6.86	1.94	− 0.8	85	0.44
Noradrenaline (nmol/l)	End of surgery	53	2.09	1.25	52	2.36	1.09	− 1.2	103	0.24
Adrenaline (nmol/l)	End of surgery	45	0.33	0.18	37	0.34	0.18	− 0.4	80	0.71
Cortisol (nmol/l)	End of surgery	53	312	154	56	353	144	− 1.4	107	0.16
SBP (mmHg)	Start of surgery	43	148	18	44	155	19.5	− 1.7	85	0.10
	During surgery	40	144	21	44	156	21	− 2.7	82	0.01
	End of surgery	23	138	22	35	149	21.5	− 1.9	56	0.06
DBP (mmHg)	Start of surgery	44	78	9	44	80	13.2	− 0.6	86	0.55
	During surgery	40	77	11	44	80	11	− 1.4	82	0.18
	End of surgery	23	75	12	35	78	11	− 0.9	56	0.33
Heart rate/min	Start of surgery	44	74	12	53	73	10	0.6	95	0.55
	During surgery	44	73	9	51	70	10	1.5	93	0.14
	End of surgery	21	76	11	33	71	8	1.8	52	0.08
Blood O_2 saturation (%)	Start of surgery	41	96	1.6	50	96	1.4	− 0.1	89	0.94
	During surgery	39	96	1.7	51	96	1.5	0.1	88	0.88
	End of surgery	21	96	1.6	33	96	1.2	− 0.5	52	0.63
Pupil diameter (mm)	During surgery	46	6.3	1.1	48	6.1	1.1	0.8	92	0.44
	End of surgery	37	5.0	1.5	38	5.1	1.39	− 0.3	73	0.76
Face-scale test	After surgery	53	2.9	1.4	56	2.6	1.2	1.1	107	0.29
	Next day	51	2.8	1.4	48	3.0	1.7	− 0.7	97	0.45
STAI state	After surgery	49	46	4.3	50	45	5.2	0.8	97	0.40
Pain (indicated)	During surgery	Pearson $\chi^2 = 11.46$; df = 1; $p < 0.01$								
Pain (remembered)	Interview after surgery	Pearson $\chi^2 = 19.21$; df = 1; $p < 0.01$								
Disturbing effect of microscope light	Interview after surgery	Pearson $\chi^2 = 2.93$; df = 2; p = 0.23								

RBA = retrobulbar anaesthesia; TA = topical anaesthesia; SD = standard deviation; df = degrees of freedom; VA = visual acuity; SBP = systolic blood pressure; DBP = diastolic blood pressure; STAI = State–Trait Anxiety Inventory.

16.00 hours on the day of surgery) about the pain they had experienced. In the same interview we asked the patients to summarize all their negative experiences related to the whole procedure (for example, the preoperative injection) (Fig. 1).

Systolic blood pressure increased during the procedure in both groups and the difference between the groups was significant (Fig. 2). Diastolic blood pressure also increased in both groups, but the difference was not significant (Fig. 3). Heart rate decreased slightly in both groups; the decrease was larger in the TA group, but again the difference was non-significant (p = 0.15). We also compared changes in blood pressure according to whether patients were receiving medication for hypertonia (85 patients) or not (30 patients). Only at the end of the procedure was the diastolic pressure significantly higher in the group receiving medication for hypertonia (p = 0.04).

The O_2 saturation level did not change significantly at any point during the procedure. The pupil diameter before/during/after the procedure was 6.2/6.2/5.0 mm in the RBA group, and 6.2/6.1/5.1 mm in the TA group. It decreased in both groups, but there were no significant differences according to type of anaesthesia.

The level of light disturbance (based on the interviews carried out after the procedure) was similar in both groups.

Cortisol levels decreased in both groups according to the time of day, but the decrease was greater in the RBA group, in which fewer patients indicated pain, compared with the TA group.

Six eyes in the TA group and 12 eyes in the RBA group were operated by less experienced surgeons; however, the difference was not significant (p = 0.11). Five patients in both groups indicated or remembered some pain.

Factors that corresponded with pain (both indicated and remembered) are shown in Table 4.

We wished to identify those parameters that had changed only according to type of anaesthesia, and not according to level of pain. For this purpose we excluded the data for patients who experienced pain (any pain at all), and compared the remaining data by group (TA/RBA). The two parameters that then showed significant differences were systolic blood pressure, which during surgery was significantly higher in the TA group ($p < 0.01$), and the serum adrenaline level, which at the end of surgery was slightly decreased in the RBA group, but increased in the TA group (p = 0.04) (Table 5).

The effect on pain of the preoperative variables and chosen parameters (e.g. type of anaesthesia, experience level of surgeon) was analysed using a logistic regression model. The choice of model was not a straightforward matter, however.

Table 6 sets out the model, which in our opinion provides the best interpretation and explanation of the results. The level of significance for all variables was < 0.05.

The predictive ability of the resulting classification table was 93%. (The model predicted no pain for 91 patients, of whom 86 did not experience any pain, whereas it predicted pain for 10 patients, eight of whom did have pain).

During the modelling process we found the variables for type of anaesthesia (drop), surgeon's level of experience and systolic blood pressure

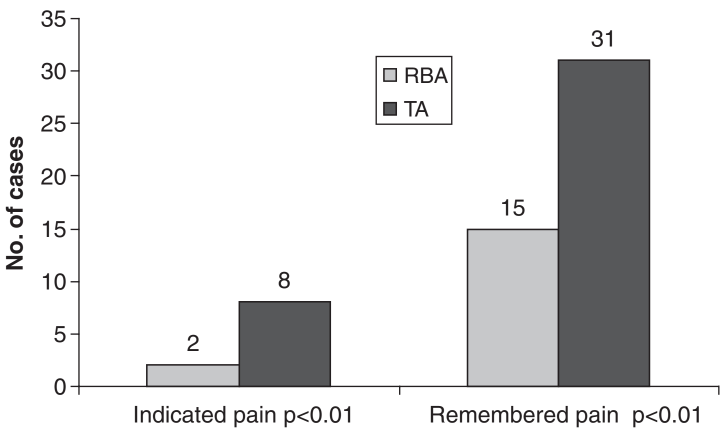

Fig. 1. Pain according to group. RBA = retrobulbar anaesthesia; TA = topical anaesthesia.

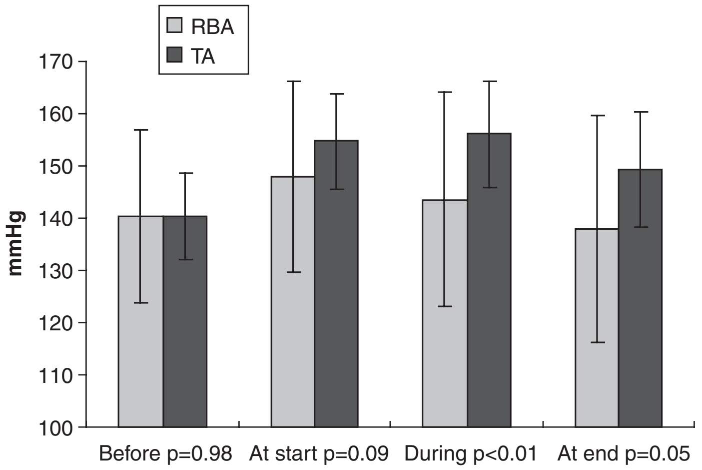

Fig. 2. Systolic blood pressure at different stages of surgery. RBA = retrobulbar anaesthesia; TA = topical anaesthesia. Results given in mean ± standard deviation.

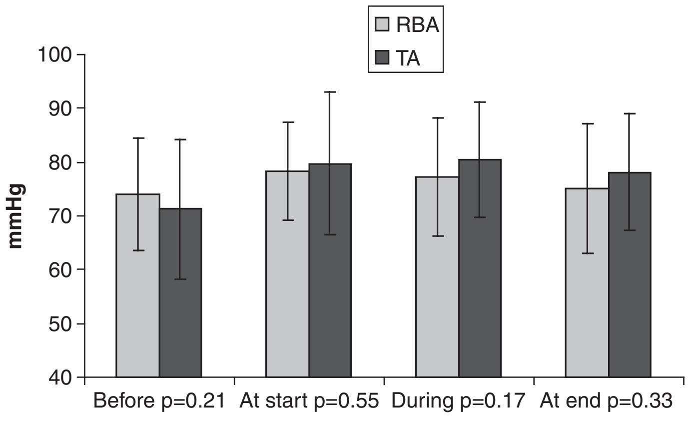

Fig. 3. Diastolic blood pressure at different stages of surgery. RBA = retrobulbar anaesthesia; TA = topical anaesthesia. Results given in mean ± standard deviation.

before surgery were robust (low systolic pressure before surgery increases sensitivity to pain). The effect of hormones (higher levels of noradrenaline and cortisol before surgery) was not significant, but it becomes significant when considered in interaction with patient age. (The effects of hormones are expressed more vividly in younger patients.)

We also repeated the analysis with a simplified model that did not include cortisol and noradrenaline levels (as such tests are expensive) (Table 7). This model was weaker in terms of its predictive ability (85%). (That is, it predicted no pain for 102 patients, in 89 of whom this was correct, whereas it predicted pain for six patients, only three of whom had pain.)

Discussion

In recent years, there has been considerable discussion in the literature about TA and RBA techniques for phacoemulsification anaesthesia (Boezaart et al. 2000; Jacobi et al. 2000; Friedman et al. 2001; Coelho et al. 2005). Most of these articles compared patient levels of pain and blood pressure and patient opinion about the procedures and the effect of light (Au Eong et al. 2000; Newman 2000; Tranos et al. 2003).

As far as we know, the present study is the first to have compared patients using RBA and TA in respect of both stimulation of the adrenocortical system and psychological changes.

Analysis of pain caused by surgery

Our results confirmed the conclusions reported in most of the literature (Friedman et al. 2001), namely that the level of pain or discomfort experienced by patients is greater with TA than it is with RBA ($p < 0.01$ in our data).

There was not only a difference between the two groups in terms of indicated pain during the operation; interviews carried out in the afternoon of the same day also revealed significant differences in remembered pain ($p < 0.01$). Indeed, the difference between the two groups in remembered pain was even more pronounced, despite the fact that patients were asked to evaluate not only the operation itself, but also the anaesthetic procedure that preceded it, including (in the case of RBA) the injection.

A possible cause of the higher incidence of pain in the TA group is that the ciliary ganglion and pain fibres from the iris or ciliary body were not blocked by the use of surface anaesthesia. Therefore, intraocular manipulation, in particular, changes in the depth of the anterior chamber and the consequent stretching of the zonulae and ciliary body or iris or iris manipulation might be expected to cause pain (Johnson 1995).

Table 4. Parameters associated with pain. Pairwise comparisons, Student's *t*-test for independent samples.

		Pain			No pain			Difference		
Data	Time of measurement	Valid N	Mean	SD ±	Valid N	Mean	SD ±	*t*-level	df	p
White blood cell count (g/l)	Difference before and after surgery	26	− 1.13	3.00	48	0.20	1.81	− 2.4	72	0.02
Cortisol (nmol/l)	Difference before and after surgery	38	103	161	63	193	155	− 2.8	99	< 0.01
SBP (mmHg)	During surgery	31	158	22	50	146	21	2.5	79	0.02
	End of surgery	24	153	26	31	138	18	2.6	53	0.01
DBP (mmHg)	During surgery	31	83	11	50	77	11	2.4	79	0.02
	End of surgery	24	82	11	31	74	11	2.3	53	0.02
Face-scale test	Interview after surgery	39	3.1	1.2	67	2.5	1.2	2.2	104	0.03

SD = standard deviation; df = degrees of freedom; SBP = systolic blood pressure; DBP = diastolic blood pressure.

Table 5. Comparison of differences by group, excluding data for patients who indicated or remembered any pain related to phacoemulsification surgery.

		RBA subgroup			TA subgroup			Difference		
Data	Time of measurement	Valid N	Mean	SD ±	Valid N	Mean	SD ±	*t*-level	df	p
Adrenaline (nmol/l)	Difference before and after surgery	34	− 0.02	0.21	13	0.10	0.16	− 2.04	45	0.05
SBP (mmHg)	During surgery	32	140	20	18	156	18	− 2.8	48	< 0.01

RBA = retrobulbar anaesthesia; TA = topical anaesthesia; SD = standard deviation; df = degrees of freedom; SBP = systolic blood pressure.

Table 6. Parameters of the regression model.

Parameter	B	SE	df	p	Exp (B)
Topical anaesthesia	4.6	1.5	1	< 0.01	101
Surgeon's experience	− 4.0	1.4	1	< 0.01	0.02
zSBP before surgery	− 1.7	0.6	1	< 0.01	0.19
zNA before surgery	15.6	6.8	1	0.02	5630210
Age × zNA before surgery	− 0.23	< 0.01	1	0.02	0.8
zCortisol before surgery	7.8	2.8	1	< 0.01	2451
Age × zCortisol before surgery	− 0.12	0.04	1	< 0.01	0.89

B = estimated parameter value; SE = error of estimated parameter value; df = degrees of freedom; Exp (B) = ODDS probability/– probability; zSBP = systolic blood pressure after normalizing data; zNA = serum noradrenaline level after normalizing data; zCortisol = serum cortisol level after normalizing data.

Table 7. Parameters of the regression model (excluding cortisol and noradrenaline).

Parameter	B	SE	df	p	Exp (B)
Topical anaesthesia	3.0	0.9	1	< 0.01	20.5
Surgeon's experience	− 2.2	0.93	1	0.02	0.12
zSBP before surgery	− 0.8	0.33	1	0.01	0.4

B = estimated parameter value; SE = error of estimated parameter value; df = degrees of freedom; Exp (B) = ODDS probability/– probability; zSBP = systolic blood pressure after normalizing data.

However, in our study we included only patients who had well dilated pupils. In those cases where patients indicated pain during the procedure, the surgeon did not report the anterior chamber becoming either shallower or deeper; moreover, the surgeon had not touched the iris and the pupil had remained dilated. Thus we may presume that the pain was caused by other factors. Furthermore, during surgery we were able to eliminate pain through the use of surface anaesthetics. We therefore conclude that the source of the pain did not lie in the nerve of the ciliary body or iris.

A further point of interest is that in both methods of anaesthesia many more patients remembered pain than actually indicated pain during the procedure. This result is in line with that reported by Cagini et al. (2006). The underlying causes for this difference, however, remain unknown and represent a suitable subject for further investigation.

Analysis of changes in blood pressure

Before surgery, systolic blood pressure (SBP) was similar in both groups. At the start of surgery, when the patients were laid on the operating table, SBP increased in both groups, but in the TA group the increase was greater. During surgery, SBP rose continuously in the TA group and decreased in the RBA group, with the difference being significant. By the end of surgery, however, the direction of change in SBP levels reversed, so that the final levels approached their original starting levels and the difference at this time decreased to become no longer significant. Similar changes were detectable in diastolic blood pressure (DBP), but here the difference between the two groups was not significant at any stage during the surgery. Our data are confirmed by earlier results in the literature (Suzuki et al. 1997). The first increase in blood pressure may be explained by the patient's being in a supine position. Later, during the surgery, the difference may perhaps be explained by the greater incidence of pain in the TA group (Oei-Lim et al. 1998). However, against this we found that, even after excluding data for those patients who experienced any pain at all, the difference in SBP was still significantly higher in the TA group.

There are results in the literature which suggest that the retrobulbar anaesthetic procedure itself could activate the adrenocortical system and increase SBP (Heine et al. 2001). In our study, however, we could not confirm this finding by comparing the data between the RBA and TA groups.

Analysis of changes according to pain

As a result of the pain and the activation of the sympathetic nerve system, we would expect increases in blood pressure, heart rate frequency, and in catecholamine and cortisol levels, and decreases in white blood cell numbers (Barker et al. 1990, 1991, 1993, 1994; Sanders et al. 1997).

We therefore compared those patients who indicated pain during surgery with those who neither indicated any pain during surgery nor remembered any afterwards. This revealed significant changes: decreases in the counts of white blood cells, and increases in SBP and DBP during surgery. Cortisol levels decreased according to the time of day, but the decrease was significantly less in those patients who indicated pain (Mutsch et al. 1996) (Table 6). Catecholamine levels and heart rate did not differ significantly between the two pain groups (pain/no pain at all).

Analysis of intracameral anaesthesia

Topical anaesthesia is often used in combination with intracameral anaesthetics to reduce pain levels (Tseng & Chen 1998; Karp et al. 2001). Research into the short- and longterm side-effects in the cornea as a result of the anaesthetics used is ongoing (Judge et al. 1997; Kadonosono et al. 1998; Guzey et al. 2002). Whether or not the anaesthetic substance reaches the vitreous and the retina is still in doubt (Liang et al. 1998). Consequently, we did not use intracameral anaesthesia as a matter of course: we planned to use it only if the patient's pain was continuous despite repeated surface anaesthesia. In this study, intracameral anaesthesia was not necessary.

However, if the intracameral anaesthetic solution is used only after the patient indicates pain, it is possible that the adrenocortical system will be activated before the supplementary anaesthesia takes effect (Karp et al. 2001).

In our clinic we generally use 1% lidocaine at the start of the operation in cases where anaesthesia via needle is contraindicated and when either a procedure with the iris might be required or a rapid change in anterior chamber depth may be expected.

Data analysis of patients who did not experience pain

We wished to separate those parameters that changed as a result of the method of anaesthesia used. We therefore compared the two methods by excluding those patients who experienced any pain at all (either indicated or remembered). In this analysis, in the TA group blood pressure was higher at every stage during the procedure compared with the RBA group, with the difference during surgery being significant. The serum level of adrenaline was stable in the RBA group. In the TA group, however, it increased, and this increase was significant, as was the difference between the two groups.

One possible explanation for the above is the patients' psychological state, and in particular their heightened concern about the possibility of pain with TA (Moon & Cho 2001). The psychological tests, however, did not show any differences between the two groups, either before or after surgery.

Another possible explanation for the activation of the adrenocortical system is that it did not occur as a result of pain, but rather as the result of stimulation of other afferentations of the eye, which were not blocked by the use of TA.

Analysis of results of psychological tests

Our psychological tests did not allow us to determine whether the remembered pain was real pain which had simply not been indicated during the surgery, or alternatively, whether the remembered pain was merely a result of the patient's more unstable psychological state, and not indicative of any real pain.

Which psychological test better reflects the patient's psychological state is still open to question. In the psychological tests there were no differences between the TB and RBA groups before surgery. The face-scale test only produced significant differences in those patients who remembered pain: there were no significant differences in patients who had indicated pain during the operation, compared with those who had not indicated any pain at all. The validity of this result is confirmed by the fact that the results were identical on both the afternoon after the operation and the following day, when a second test was carried out by a different interviewer ($p = 0.04$, $p < 0.01$, respectively).

The STAI state and trait test results did not correlate with type of anaesthesia, pain or any other factors. On the basis of these results, which are in line with those in the literature, the usefulness of this test with patients of this age group is questionable (Schaffer et al. 1988).

Factors that had an effect on patient pain

Our other objective was to find parameters that might help predict a given patient's sensitivity to pain. Using a logistic regression model, we were in fact able to predict this with 93% certainty. We found that, besides the type of anaesthesia used, the experience level of the surgeon and lower SBP were robust predictive variables. In addition, cortisol and noradrenaline levels of patients before surgery had an effect on patients' sensitivity to pain, but this effect was significant only in combination with age. (The effect of hormones is more pronounced in younger patients.)

When we excluded cortisol and noradrenaline levels (factors only measurable with expensive laboratory tests) from the model, the predictive power fell to 85%.

The length and complexity of the operation had no effect on the level of pain (Zs Biró 1998; O'Brien et al. 2001).

Conclusions

If we summarize our results, we can conclude that phacoemulsification using TA is more painful for patients than that using RBA, and the patient's physiological parameters change as a result.

Cortisol levels change according to pain and adrenaline levels change according to the type of anaesthesia (RBA or TA), whereas SBP is influenced by both factors. Younger patients who have higher levels of cortisol and noradrenaline before surgery are more susceptible to pain during the procedure.

Using a logistic model on our patients, we could have predicted the possibility of pain with 93% certainty and adjusted our planned anaesthetic methods accordingly. Furthermore, higher SBP can be expected during surgery using TA as opposed to RBA. Therefore, in patients who are more susceptible to high BP, alternative methods of anaesthesia are recommended.

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