Early postoperative intraocular pressure elevation following cataract surgery at a tertiary training hospital

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Introduction

Cataracts are a leading cause of poor vision and blindness in South Africa (1), hence cataract surgery is one of the most commonly performed surgeries. Cataract surgery is a safe procedure, with complications occurring in less than 5% of patients. (2) Post-operative complications range from corneal oedema, wound leak, iris prolapse, intraocular lens dislocation, inflammatory and infective complications, as well as intraocular pressure (IOP) elevation.

Early IOP spikes have been found to occur in up to 8% of cases. (3) Authors are not in agreement about the definition of an “IOP spike”. Values of 21mmHg up to 30mmHg have been used in various articles (3–7), while some authors prefer to use an increase of 10mmHg from baseline and others opt to use a relative value, for example, a 50% increase in IOP. (7) Although it is usually transient, it can result in significant patient discomfort, severe eye and brow pain, nausea, vomiting, compromised visual function, and rarely, permanent vision loss.

Transient IOP elevation after cataract surgery can cause visual field constrictions, anterior ischaemic optic neuropathy, and central retinal vein occlusions in glaucomatous eyes. (3,8). In non-glaucomatous eyes, iris ischaemia, delayed wound healing and cystoid macula oedema have been reported. (4)

Numerous authors agree that the peak post-operative pressure occurs within the first 3-7 hours following surgery. (7,9,10) The pathogenesis for early IOP elevation is multifactorial. Inflammation and prostaglandin release following surgical trauma

remains the biggest culprit. Mechanical deformation of the anterior chamber structures, haemorrhage, pigment dispersion, retained lenticular material, and residual ophthalmic viscoelastic device (OVD) have been implicated. (10) Furthermore, the type of OVD also plays a role in the postoperative IOP. The molecular structure of dispersive OVD is more difficult to remove as it tends to adhere to intraocular structures, resulting in higher IOP. (7,11)

Risk factors for early postoperative IOP spikes include the type of cataract surgery, elevated pre-operative intraocular pressure, longer axial length, Tamsulosin use, post-operative topical corticosteroid use, and registrar-performed surgery. (6) Intra-operative complications are also closely related to postoperative IOP spikes. Complications associated with IOP spikes include vitreous loss, anterior capsular tear, posterior capsular tear, as well as zonulysis. (12)

As mentioned earlier, registrar-performed surgeries are a known risk factor for early IOP spikes. Elfersy et al. have shown that postoperative IOP can be 2 to 5 times higher when surgery is performed by junior surgeons, compared to that of experienced surgeons. (13) This could be due to a longer surgery time, more surgical trauma and incomplete OVD washout. (13)

Holm states that good IOP-lowering effects can be gained by a single postoperative treatment dose. (14) Implementing a single-dose prophylactic treatment strategy would be cost-effective and unlikely to cause significant systemic side effects. Current literature suggests the use of topical medication that contains Timolol, although a single dose of oral Acetazolamide has also been used with success. (14)

One study showed that patients who had immediate same-day intervention maintained an IOP lower than 21mmHg. The IOP lowering effect was maintained at the day 1 follow up and by day 4, most patients had an IOP below preoperative levels. (4)

No drug has been found to completely prevent early postoperative IOP spikes. (7,15) Furthermore, opinions regarding the optimal treatment protocol are diverse. There is no standard pharmacological regimen to guide the decision-making process about these IOP spikes.

In summary, elevated intraocular pressure is a common complication and occurs in the first 3-7 hours following cataract surgery. It is a treatable and mostly preventable complication that can result in unnecessary patient discomfort and potential long-term complications. This study aims to establish the prevalence of early elevated IOP following uncomplicated cataract surgery.

Methods

This study had a prospective cohort design. Ethical clearance was obtained from the Human Research Ethics Committee, University of Witwatersrand (M221047). Permission was granted by Chris Hani Baragwanath Academic Hospital to conduct the study.

The study population consisted of all patients who underwent registrar-performed cataract surgery between February 2023 and October 2023 at St John's Eye

Hospital, Soweto, Gauteng. Only patients who accepted to participate and completed the informed consent form were considered. Participation was confirmed if the cataract surgery was uneventful.

Inclusion criteria:

1. Age-related cataracts
2. Uncomplicated cataract surgeries performed by registrars in years 2 to 4 of training
3. Cataract surgery type: phacoemulsification

Exclusion criteria:

1. Patients with glaucoma (primary or secondary)
2. Conditions associated with glaucoma: previous uveitis and pseudoexfoliation syndrome
3. Patients who have eyes with optic nerves suggestive of glaucomatous changes
4. Patients with ocular hypertension
5. Complicated cataract surgery, including posterior capsule rent, vitreous loss, iridodialysis, and haemorrhage
6. Patients with previous eye trauma or ocular surgery
7. Axial length < 22.0mm and > 25.0mm
8. Tamsulosin use before surgery

Each patient eligible and willing to participate in this study had a data collection sheet, which included the age and gender of the patient, the side of the eye being operated, the time that surgery was finished, the time that the IOP measurement was

taken, the time elapsed between these two occasions, the IOP in mmHg and the year of training of the surgeon. (Appendix 1)

Patients underwent routine phacoemulsification under a peribulbar block. After 3-7 hours the intraocular pressure was measured with an iCare tonometer. Pressure was considered elevated if it was over 20mmHg. Patients with raised IOP were further grouped according to the IOP, <20, 20-30, >30mmHg. If the intraocular pressure was found to be above 20mmHg, treatment was immediately given in the form of 500mg Diamox orally.

The sample size for prevalence was determined using the formula $n = (Z^2P(1-P))/d^2$, where n is the sample size, Z is the Z-statistic for the chosen level of confidence, P is the expected prevalence and d is the precision. A 95% confidence interval was used, 6% precision and from literature we know that the estimated prevalence is 8%. This brought the sample size to 80 patients.

All baseline study variables were compared between surgeon groups (year of study - YOS) to determine differences in case mix between the groups. Categorical variables (gender, eye operated) were assessed by the X2 test. Fisher's exact test was used where the requirements for the X2 test could not be met. Continuous variables (age, time to measurement) were assessed by one-way Analysis of Variance (ANOVA). Where the data did not meet the assumptions of this test, a non-parametric alternative, the Kruskal-Wallis test was used.

The relationship between each study variable and the post-operative IOP category was assessed using multinomial logistic regression, with the <20 mmHg IOP category as the reference category

Data analysis was carried out in Stata. A 5% significance level was used.

Results

The demographics of the study population are summarized in Table I. Eighty patients were recruited during the study period. The mean age was 68 years old, with a range of 47-87 years old. Fifty-seven (71%) patients were female and 23 (29%) were male. The right eye was operated in 41 (51%) patients, while 39 (49%) received surgery to the left eye.

Table I. Patient demographics

Patient demographics					
		Overall	YOS 2	YOS 3	YOS 4
Total in group		80	32	20	28
Mean age (years)		68	70	67	68
Gender	Female	57	24	13	20
	Male	23	8	7	8
Eye	Right	41	16	11	14
	Left	39	16	9	14

The median time between surgery completion and IOP measurement was 3h30 (ranging from 3h00 to 6h20). The overall mean IOP was 23mmHg with a range between 2mmHg - 59mmHg (Table II). The average IOP in the YOS 2 group was 23mmHg (7mmHg – 59mmHg), while the YOS 3 group average was 24mmHg (2mmHg – 43mmHg) and the YOS 4 group average was 23mmHg (2mmHg – 41

mmHg). Of the 80 patients, 50 (62.5%) had an IOP of >20mmHg, and 19 (23.7%) had an IOP of >30mmHg. There was a total of 32 patients in the YOS 2 group, 20 patients in the YOS 3 group, and 28 patients in the YOS 4 group.

Table 2. IOP (mmHg) measurements

IOP measurements					
		Overall	YOS 2	YOS 3	YOS 4
Time elapsed: median (IQR)		3.5 (3.2-4.4)	3.7 (3.2-4.7)	3.2 (3.2-3.5)	3.8 (3.2-4.4)
IOP; range		23; 2-59	23; 7-59	24; 2-43	23; 2-41
IOP grouped	< 20	30	13	5	12
	20-30	31	15	9	7
	> 30	19	4	6	9

Time elapsed: time between surgery completion and IOP measurement
IQR: interquartile range
IOP: intra-ocular pressure
YOS: year of study

There was no significant association between any of the study variables and the YOS of the surgeon. We also note that there was no significant association between the IOP category and YOS of the surgeon (p=0.21), as illustrated below in Figure 1.

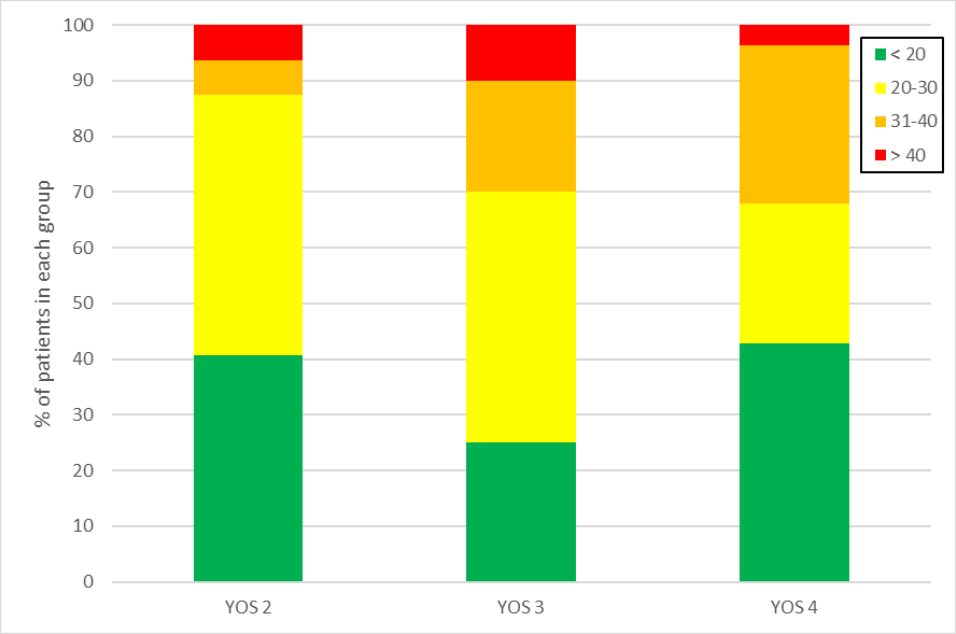

Figure 1. Distribution of IOP between YOS groups

Age, gender, eye, the time between surgery and IOP measurement, and YOS of the surgeon, were not significantly associated with increased IOP.

Table 3. Odds ratios for different patient characteristic

Characteristic	**Category**	**Odds Ratio (95% CI) for IOP 20-30 vs <20 mmHg**	**Odds Ratio (95% CI) for IOP >40 vs <20 mmHg**
Age (years): mean (SD); range		1.00 (0.93-1.06)	1.02 (0.94-1.10)
Gender	Female	1.00 (reference)	1.00 (reference)
	Male	1.34 (0.43-4.24)	1.92 (0.54-6.75)
Eye	Left	1.00 (reference)	1.00 (reference)
	Right	0.63 (0.23-1.73)	0.85 (0.27-2.69)
Time elapsed (hours): median (IQR); range		0.83 (0.45-1.52)	0.88 (0.44-1.75)
YOS of surgeon	2	1.00 (reference)	1.00 (reference)
	3	1.56 (0.42-5.85)	3.90 (0.76-20)
	4	0.51 (0.15-1.66)	2.44 (0.59-10)

Time elapsed: time between surgery completion and IOP measurement

YOS: year of study

Discussion

This study aimed to establish the prevalence of early elevated IOP following uncomplicated cataract surgery. Fifty of the 80 patients (62.5%) had an early post-operative IOP of 20mmHg or more. The first post-operative follow-up visit, which includes IOP measurement, is routinely done 24 hours after surgery, which means that many patients with elevated IOP are going undetected.

The main cause of these pressure spikes is postulated to be due to retained OVD, which mechanically obstructs the trabecular meshwork. (16) Therefore, it is essential to thoroughly wash out all the OVD. Removal of OVD behind the IOL is critical to prevent IOP spikes, IOL decentration, and capsular block syndromes. (7) Surgical techniques of IOL implantation without the assistance of OVD have been suggested to mitigate this risk.

Subconjunctival corticosteroids at the end of surgery are commonly used at our facility. This can also be associated with higher IOPs. However, corticosteroid use will likely result in a prolonged IOP rise, rather than a transient elevation. (7)

In our study, the degree of IOP elevation was not related to the registrar's years of study. This result was not in keeping with our hypothesis, as beginner surgeons often have longer operative times and more tissue manipulations resulting in a greater inflammatory response and more iris pigment release. (9)

On the other hand, we have also noted that some patients had very low post-operative IOPs. This can be explained by suboptimal anterior chamber inflation at

the end of surgery or wound leaks. (3) Ciliary body shutdown can also occur after peribulbar anaesthesia. It can be a direct effect of the anaesthetic agent on aqueous production, but also because of reduced choroidal blood flow with secondary ciliary body hypoperfusion. (3)

In our study, we specifically excluded patients with glaucoma, as these eyes are in a higher risk category to develop post-operative IOP elevation. Ahmed et al found that the pressure spikes occur more often and with greater magnitude when compared to non-glaucomatous eyes. (4) Numerous authors agree that a diagnosis of glaucoma and ocular hypertension is a significant risk factor for raised IOP following surgery. (3)

Limitations to this study include a small sample size. Furthermore, a single investigator collected the data for this study, which may have resulted in unintended bias. A rebound tonometer, the iCare, was used to measure all the IOPs. Goldmann applanation tonometry (GAT) remains the reference standard when measuring intraocular pressure, but rebound tonometry (RT) is a safe alternative in patients with IOP in the low to moderate range. The accuracy of RT becomes less in higher IOP ranges when compared to GAT. (17) We were more interested in the IOP trend, rather than the exact IOP value. Furthermore, the iCare was considered a safer option due to the absence of disposable tonometry tips for the GAT.

Future studies could investigate the effect of different OVDs on early postoperative IOP elevation. The central corneal thickness in the postoperative eye can be investigated, as well as the effect of cataract surgery on IOP in glaucomatous eyes.

Conclusion

Early IOP elevation following phacoemulsification is a known and frequent complication. (6) This study found that more than half of the patients who underwent phacoemulsification at a tertiary ophthalmology hospital had an IOP > 20mmHg in the first 3-7 hours following surgery. Trainee surgeons can consider prophylactic IOP lowering treatment, especially in high-risk groups.

Acknowledgments

Dr. Petra Gaylard for assistance with data analysis.

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APPENDIX 1

Data collection tool

1. **Age**

2. **Gender**

Male ☐ Female ☐

3. **Eye operated**

Right ☐ Left ☐

4. **The time the surgery finished**

5. **The time that measurement is taken**

6. **Time elapsed between surgery and intraocular pressure measurement**

7. **Intraocular pressure measurement in mmHg**

8. **Years of training of the surgeon**

2nd year ☐ 3rd year ☐ 4th year ☐

APPENDIX 2

WITS UNIVERSITY

PARTICIPANT CONSENT SHEET

Early postoperative intraocular pressure elevation following cataract surgery at a tertiary training hospital

1. I have been given a Participant Information Sheet which explains the nature and processes involved in this study, which is attached hereto;
2. I was given time to read it, or had it read to me, in the language I best understand;
3. I was given time to ask any questions I wanted to and found any answers given to me to be reasonable and satisfactory;
4. I believe I fully understand why the study is being conducted and what the intended outcomes will be;
5. I understand that there will be no immediate benefit to me, should I agree to participate, nor will I receive any payment; conversely, participation will not cost me anything but my time;
6. I understand that, even if I initially consent to take part in the study, I may subsequently withdraw at any time and would not be required to give any reasons; if that happened, any data collected about me for the purposes of the study would immediately be destroyed, unless I give consent for it to be retained
7. I have been given a range of contact details, listed below. If I require further information or become concerned about any aspect of this study, I am free to speak to any of these contacts.

Contact details:

Dr. Estelle Jansen, Principal Investigator, telephone no. 072 988 8484, or by e-mail at steljansen@gmail.com,

Dr. Roland Höllhumer, Supervisor, on telephone no. 011 782 1080, or by e-mail at hollhumer@gmail.com

Professor CB Penny, Chairperson of the Human Research Ethics Committee (Medical) at the University of Witwatersrand, on telephone no. 011 717 2301, or by e-mail at Clement.Penny@wits.ac.za.

Ms. Z Ndlovu or Mr Rhulani Mkansi, Committee Secretariat, telephone nos.: 011 717 2700 or 1234, or by e-mail at: Zanele.Ndlovu@wits.ac.za or Rhulani.Mkansi@wits.ac.za

Participant	Witness
Name: _____	Name: _____
Date: _____	Date: _____
Place: _____	Signature: _____
Signature or mark: _____	

APPENDIX 3

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG

R49 Dr E Jansen

HUMAN RESEARCH ETHICS COMMITTEE (MEDICAL)
CLEARANCE CERTIFICATE NO. M221047

NAME: (Principal Investigator)	Dr E Jansen
DEPARTMENT:	School of Clinical Medicine Department of Neurosciences Division of Opthalmology St John's Eye Hospital Chris Hani Baragwanath Academic Hospital
PROJECT TITLE:	*Early postoperative intraocular pressure elevation following cataract surgery at a tertiary training hospital*
DATE CONSIDERED:	2022/10/28
DECISION:	Approved unconditionally
CONDITIONS:	
NOTE:	If contact information regarding student study participants is required, please contact the Registrar's office - <Nicoleen.Potgieter@wits.ac.za>
SUPERVISOR:	Dr R Höllhumer
APPROVED BY:	Dr CB Penny, Chairperson, HREC (Medical)
DATE OF APPROVAL:	2023/01/16

This Clearance Certificate is valid for 5 years from the date of approval. An extension may be applied for.

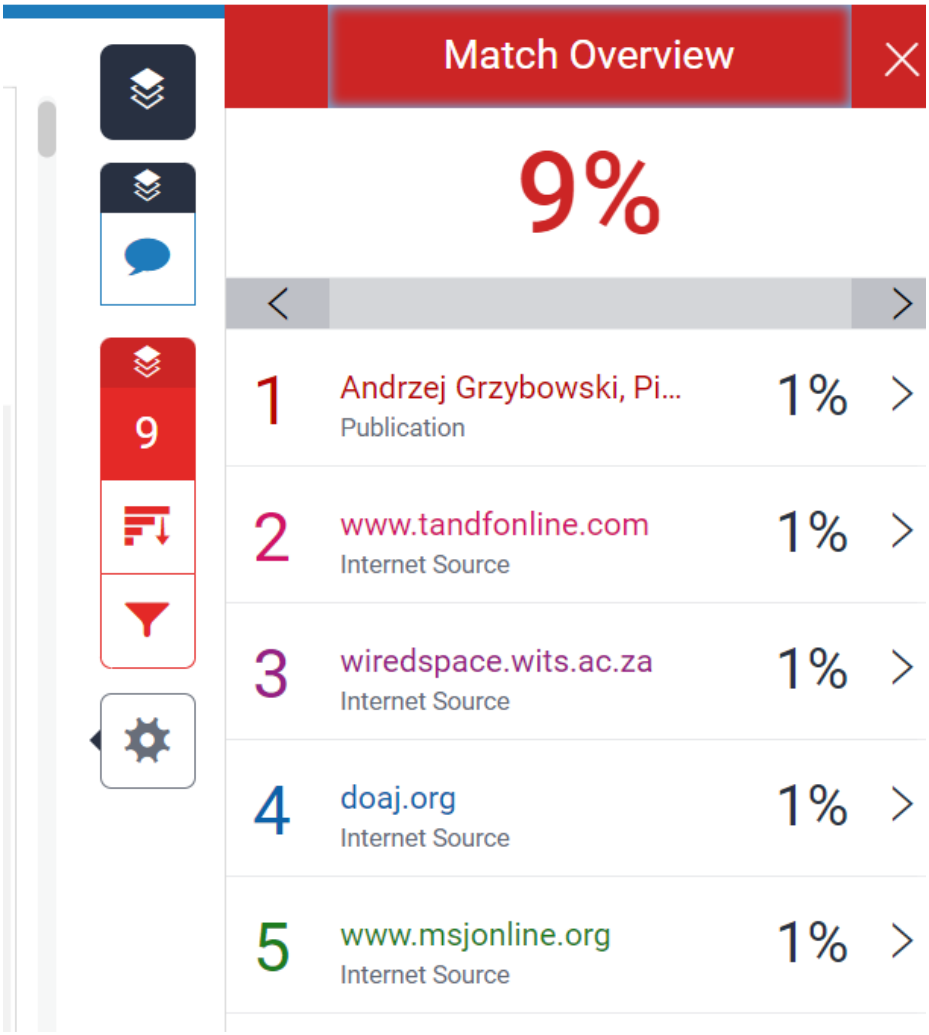
DECLARATION OF INVESTIGATORS

To be completed in duplicate and **ONE COPY** returned to the Research Office secretariat on the 3rd floor, Phillip Tobias Building, Parktown, University of the Witwatersrand, Johannesburg.

I/we fully understand the conditions under which I am/we are authorized to carry out the above-mentioned research and I/we undertake to ensure compliance with these conditions. Should any departure be contemplated from the research protocol as approved, I/we undertake to submit details to the Committee. **I agree to submit a yearly progress report**. When a funder requires annual re-certification, the application date will be one year after the date when the study was initially reviewed. In this case, the study was initially reviewed in **October** and therefore reports and re-certification will be due in the month of **October** each year. Unreported changes to the study may invalidate the clearance given by the HREC (Medical).

Signature of Principal Investigator Date

APPENDIX 4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