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# EFFECTS OF CATARACT SURGERY ON SHORT-TERM INTRAOCULAR PRESSURE FLUCTUATIONS IN PATIENTS WITH PRIMARY ANGLE-CLOSURE AND PRIMARY ANGLE-CLOSURE GLAUCOMA

## *UTICAJ OPERACIJE KATARAKTE NA KRATKOTRAJNE FLUKTUACIJE INTRAOKULARNOG PRITISKA KOD PACIJENATA SA PRIMARNIM ZATVARANJEM UGLA I PRIMARNIM GLAUKOMOM ZATVORENOG UGLA*

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**Summary**
**Introduction.** Cataract surgery results in a reduction of intraocular pressure, but it has not been sufficiently investigated how it affects short-term intraocular pressure fluctuations. The aim of this study was to evaluate the effects of cataract surgery on short-term intraocular pressure fluctuations in patients with primary angle-closure, with or without glaucoma. **Material and Methods. A** prospective interventional clinical study included 31 patients (eyes) with primary angle-closure/primary angle-closure glaucoma (study group) and 31 patients (eyes) with cataract only (control group). All subjects underwent cataract surgery. Preoperatively, and at the first, third and sixth postoperative months, diurnal tension curves for the assessment of intraocular pressure was performed and the mean intraocular pressure and short-term intraocular pressure fluctuations were evaluated. **Results.** Postoperatively, the mean intraocular pressure and short-term intraocular pressure fluctuations were significantly reduced in both groups. In the study group, the highest mean intraocular pressure reduction was - 4.14 ± 2.50 mmHg, and in the control group it was - 2.44 ± 1.76 mmHg. The highest reduction of short-term fluctuations was - 1.61 ± 3.55 mmHg in the study group, and - 0.55 ± 1.72 mmHg in the control group. In both groups, a significant negative correlation was found between the preoperative and postoperative mean intraocular pressure and short-term intraocular pressure fluctuations. At the end of the research, the number of medications was reduced by 18.4% compared to the preoperative period. **Conclusion.** Cataract surgery in patients with primary angle-closure/primary angle-closure glaucoma results in a significant reduction of intraocular pressure, short-term intraocular pressure fluctuations, and a reduction in the number of medications.
**Key words:** Glaucoma, Angle-Closure; Glaucoma; Intraocular Pressure; Cataract Extraction; Ophthalmologic Surgical Procedures; Treatment Outcome

**Sažetak**
**Uvod.** Operacija katarakte rezultira sniženjem intraokularnog pritiska ali je nedovoljno ispitano kako utiče na njegove kratkoročne fluktuacije. Cilj ove studije je bio da ispitamo uticaj operacije katarakte na kratkoročne fluktuacije intraokularnog pritiska kod osoba sa primarnim zatvaranjem komornog ugla, sa glaukomom ili bez njega. **Materijal i metode.** U prospektivnu intervencijsku kliničku studiju je uključen 31 pacijent (oko) sa primarnim zatvaranjem ugla/primarnim glaukomom zatvorenog ugla (eksperimentalna grupa) i 31 pacijent (oko) samo sa kataraktom (kontrolna grupa). Svim ispitanicima je urađena operacija katarakte. Preoperativno, prvi, treći i šesti mesec postoperativno, sproveden je test dnevne krive intraokuluarnog pritiska i ispitani su prosečni intraokularni pritisak i njegove kratkoročne fluktuacije. **Rezultati.** Postoperativno, prosečni intraokularni pritisak i njegove kratkoročne fluktuacije su, u obe grupe, značajno redukovani. Najveća redukcija prosečnog intraokularnog pritiska u eksperimentalnoj grupi iznosila je -4.14 ± 2,50 mmHg, a u kontrolnoj grupi -2.44 ± 1,76 mmHg. Najveća redukcija kratkotrajnih fluktuacija za eksperimentalnu grupu iznosila je -1,61 ± 3,55 mmHg, a za kontrolnu grupu, -0,55 ± 1,72 mmHg. U obe grupe utvrđena je značajna negativna korelacija između preoperativnog prosečnog intraokularnog pritiska i njegovih kratkotrajnih fluktuacija sa njihovom postoperativnom promenom. Na kraju istraživanja, broj medikamenata je redukovan za 18,4% u odnosu na preoperativni broj. **Zaključak.** Operacija katarakte kod pacijenata sa primarnim zatvaranjem ugla/primarnim glaukomom zatvorenog ugla rezultira značajnom redukcijom intraokularnog pritiska, njegovih kratkotrajnih fluktuacija i broja lekova.
**Ključne reči:** glaukom zatvorenog ugla; glaukom; intraokularni pritisak; ekstrakcija katarakte; oftalmološke hirurške procedure; ishod lečenja

## Introduction

Globally, cataract and glaucoma are the two leading causes of blindness [1] and often, at a certain point, they may occur together in the same person. Increased intraocular pressure (IOP) is the most significant risk factor for the occurrence and progression of glaucoma and, for now, the only one that can be modified [2, 3]. Some studies identify large diurnal fluctuations in IOP as an independent risk factor

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***Abbreviations***

IOP – intraocular pressure
PACG – primary angle-closure glaucoma
PAC – primary angle-closure
BCVA – best-corrected visual acuity
ICA – iridocorneal angle
DTC – diurnal tension curves
IOPav – average IOP
IOPst – short-term daily fluctuation of IOP
PHACO – phacoemulsification method
CAI – carbonic anhydrase inhibitors
GAT – Goldmann applanation tonometer

for the development and progression of glaucoma [4]. The traditional treatment of glaucoma includes ocular hypotension drugs applied locally or systemically, laser systems or filtration surgeries. It is well known that cataract surgery leads to IOP reduction, both in glaucoma, and in nonglaucoma patients, although with different clinical significance depending on the type of glaucoma [5–9]. Primary angle-closure glaucoma (PACG), compared to other types of glaucoma, carries a much higher risk of bilateral blindness due to a specific pathomechanisms [10]. The PACG is preceded by primary angle-closure (PAC). Results of previous research on the effects of cataract surgery on the lowering of IOP in patients with PAC/PACG, point to cataract surgery as part of the treatment, and for some patients, as the first and the only therapeutic approach [11]. Due to challenges in data collection, there are only a few studies that have investigated the effects of cataract surgery on short-term IOP fluctuations in patients with PAC/PACG and the aim of this study was to examine this relationship, believing that our results will contribute to a better understanding of the disease and help physicians make the most favorable decision about the therapeutic approach.

## Material and Methods

The study was conducted at the University Clinical Center of the Republic of Srpska, Bosnia and Herzegovina, from December 2019 to December 2020. The research was done in accordance with the Helsinki Declaration and all the subjects signed an informed consent which had been approved by the Ethics Committee of the Institution.

The prospective intervention clinical study included 31 patients (31 eyes) with the diagnosis of PAC/PACG (PAC/PACG group) and 31 patients (31 eyes) with senile/presenile cataract (control group, Cataract).

Inclusion criteria for PAC/PACG group were: bilateral presence of iridotrabecular contact of $\geq 180^\circ$ on gonioscopy; gonioscopy findings of grade 2, 1 or 0 using the Shaffer grading system [12]; IOP > 21 mmHg in the period when the diagnosis was established or findings of peripheral anterior synechiae (PAS); absence of glaucomatous optic neuropathy in patients with PAC and its presence in patients with PACG; visual field defects in patients with PACG; presence of clinically significant cataract or absence of clinically significant cataract if clinical examination indicated benefits from clear lens extraction.

Inclusion criteria for the Cataract group were: clinically significant cataract with best-corrected visual acuity (BCVA) $\leq 0.5$ optotype according to a Snellen chart; bilateral gonioscopic findings of grade 4 or 3 according to Shaffer; bilateral IOP $\leq 21$ mmHg.

Exclusion criteria for both groups were: previous eye injury, inflammatory and/or degenerative disease of ocular adnexa, as well as of the anterior or posterior eye segment, retinal disease, non-glaucomatous optic neuropathy, long-term use of corticosteroids (systemic and topical) or intraocular surgical or laser intervention except neodymium-doped yttrium aluminium garnet iridotomy in patients with PAC/PACG; operative and postoperative periods with complications.

Before the surgery, basic demographic data were collected, BCVA was established, slit-lamp examination was done, one measurement of IOP was obtained using Goldmann applanation tonometry, grading of the iridocorneal angle (ICA) was done and "gonioscopy score" was calculated [13]. Biometric measurements were performed by non-contact method using IOLMaster 500 biometer (Carl Zeiss Meditec, Inc., Dublin, CA) and contact applanation A-scan ultrasound biometry (Tomey, AL-100 Biometer, Japan). The number and types of glaucoma medications were registered. Diurnal tension curves (DTC) test of intraocular pressure was done with measurements at 07:30, 13:30 and 19:30 and the average IOP (IOPav) was calculated using the formula: IOPav 3.

Short-term (st) daily fluctuation of IOP was calculated using the formula: IOPst = IOP maximum – IOP minimum.

The criteria for the selection of an eye for surgery in the Cataract group was the eye with worse BCVA, and in the PAC/PACG, it was the eye with higher IOP.

The surgery was performed under topical anesthesia with phacoemulsification (PHACO), "in-the-bag" "phaco-chop" technique with intraocular leus implantation (Akreos Adapt AO, Bausch&Lomb) through 2.75 mm incision, using Stellaris Vision Enhancement System (Bausch&Lomb) device.

For the purpose of the study, a routine four-week treatment protocol was modified to prevent the potential effect of corticosteroids on the intraocular leus level, and all subjects stopped receiving corticosteroid drops after the second week, and continued with non-steroidal anti-inflammatory eye drops until the end of the first month. In the PAC/PACG group, already on the first postoperative day, all the subjects stopped receiving miotics and systemic carbonic anhydrase inhibitors (CAI). Some subjects stopped receiving prostaglandin analogues for one month or permanently if the monitoring showed that IOP was lowered, reaching the target value. Those patients received beta blocker drops or topical CAI if they had not been used preoperatively or the daily dosage of topical CAI was increased from 2 to 3 times a day. The criterion for adjusting the therapy was the postoperative level of IOP $\leq 21$ mmHg.

Controls were performed on the 1st and 7th postoperative days, as well as after 1, 3 and 6 months. Controls after 1, 3 and 6 months included DTC. All clinical examinations and surgeries were performed by the same surgeon (B. M.).

Statistical analysis was performed using IBM SPSS Statistics 21.0 software. The Pearson's chi-square test, Mann-Whitney U test, Student's t-test, Kruskal-Wallis H test, Bonferroni test, Wilcoxon signed-rank test and Spearman's rank correlation test were used. Data were statistically processed and $p < 0.01$ and $p < 0.05$ were considered statistically significant.

## Results

The PAC/PACG group included 19 women (61.3%) and 12 men (38.7%), and in the Cataract group there were 16 women (51.6%) and 15 men (48.4%). The average age in the PAC/PACG group was 72 ± 8 (range 55 - 89) and somewhat younger in the Cataract group, 71 ± 7 (range 53 - 82). There was no statistically significant difference in the gender ($\chi^2$ (1. 62) = 0.59; p = 0.442) or age distribution (Mann-Whitney U test; p = 0.059) between the two groups.

The average preoperative BCVA in the PAC/PACG group was 0.33 ± 0.23 (range 0.03 - 1), and in the Cataract group 0.16 ± 0.15 (range 0 - 0.6). Already on the first postoperative day, and at each time point of the follow-up, both groups presented with a statistically significant improvement of BCVA compared to the preoperative value (Wilcoxon signed-rank test; p < 0.01). After 6 months, in the PAC/PACG group the BCVA was 0.81 ± 0.28 (range 0.2 - 1), and in the Cataract group 0.97 ± 0.06 (range 0.8 - 1). Bonferroni test showed that the PAC/PACG group had a statistically significantly higher preoperative BCVA (p < 0.01), and postoperatively, on each control visit, significantly lower BCVA compared to the control group (p < 0.01).

Preoperative and postoperative values of IOPav and IOPst in both groups are shown in **Table 1**.

**Table 1.** Descriptive data for the mean intraocular pressure and the short-term intraocular pressure fluctuations per group and time points
***Tabela 1.*** *Deskriptivni podaci za varijable prosečni intraokularni pritisak (IOPav) i kratkoročne fluktuacije intraokularnog pritiska (IOPst) po grupama i vremenskim odrednicama*

| | PAC/PACG/*PAC/PACG* (N/*Br.* = 31) M ± SD (range/*opseg*) | Cataract/*Katarakta* (N/*Br.* = 31) M ± SD (range/*opseg*) |
|---|---|---|
| Preoperatively/*Preoperativno* | | |
| IOPav (mmHg) | 17.98 ± 3.03 (13.03 - 26.53) | 14.53 ± 2.04 (10.67 - 19.7) |
| IOPst (mmHg) | 4.24 ± 3.67 (0.9 - 19) | 2.79 ± 1.46 (0 - 5.4) |
| 1 month/*1. mesec* | | |
| IOPav (mmHg) | 14.74 ± 3.09 (5.53 - 21) | 13.53 ± 2.22 (9.57 - 17.63) |
| IOPst (mmHg) | 2.9 ± 1.66 (0.7 - 8.8) | 2.4 ± 1.34 (0.3 - 4.7) |
| 3 month/*3. mesec* | | |
| IOPav (mmHg) | 14.13 ± 2.48 (9.13 - 20.47) | 12.09 ± 2.03 (7.67 - 15.6) |
| IOPst (mmHg) | 2.63 ± 1.63 (0.7 - 7.9) | 2.37 ± 1.06 (0.9 - 4.8) |
| 6 month/*6. mesec* | | |
| IOPav (mmHg) | 13.84 ± 2.32 (9.3 - 18.43) | 12.27 ± 1.89 (9.37 - 15.77) |
| IOPst (mmHg) | 2.87 ± 1.47 (0.4 - 7.6) | 2.24 ± 1.17 (0.3 - 4.9) |

Legend: PAC/PACG – primary angle closure/primary angle-closure glaucoma; IOPav – average intraocular pressure; IOPst – short-term intraocular pressure; M – mean; SD – standard deviation
*Legenda: PAC/PACG – primarno zatvarajući ugao/primarni glaukom zatvarajućeg ugla; IOPav – prosečni intraokularni pritisak; IOPst – kratkoročne fluktuacije intraokularnog pritiska; M – prosek; SD – standardna devijacija*

**Table 2.** Descriptive data for the absolute and relative postoperative changes in the mean intraocular pressure
***Tabela 2.*** *Deskriptivni podaci za apsolutnu i relativnu postoperativnu promenu prosečnog intraokularnog pritiska*

| | Δ IOPav 1 month/Δ *IOPav 1. mesec* M ± SD (mmHg) (%) | Δ IOPav 3 month/Δ *IOPav 3. mesec* M ± SD (mmHg) (%) | Δ IOPav 6 month/Δ *IOPav 6. mesec* M ± SD (mmHg) (%) |
|---|---|---|---|
| PAC/*PACG* N/*Br.* = 31 | - 3.24 ± 2.91 (- 17.28) | - 3.85 ± 2.25 (- 20.72) | - 4.14 ± 2.50 (- 22.18) |
| Cataract *Katarakta* N/*Br.* = 31 | - 1.00 ± 1.73 (- 6.54) | - 2.44 ± 1.76 (- 16.40) | - 2.26 ± 1.71 (- 15.06) |

Legend: PAC/PACG – primary angle closure/primary angle-closure glaucoma; Δ IOPav - postoperative change in the mean intraocular pressure; M - mean; SD - standard deviation
*Legenda: PAC/PACG – primarno zatvarajući ugao/primarni glaukom zatvarajućeg ugla; Δ IOPav – postoperativna promena prosečnog intraokularnog pritiska; M – prosek; SD – standardna devijacija*

Wilcoxon test established that in both groups postoperative values of IOPav at any time of measurement were significantly lower ($p < 0.01$) compared to the preoperative IOPav. A significant difference between the postoperative IOPst and its preoperative value was established only in the PAC/PACG group in the first ($p < 0.05$) and the third postoperative month ($p < 0.01$).

Preoperatively, the Bonferroni test registered a significantly lower value of IOPav in the Cataract group compared to the PAC/PACG group (- 3.441; $p < 0.01$) and postoperatively in the 3rd (- 2.036; $p < 0.01$) and the 6th month (- 1.561; $p < 0.05$). At each time point of the check-up, no statistically significant difference between the observed groups was registered for IOPst.

The postoperative change of IOPav and IOPst compared to their preoperative values was expressed through their absolute and relative change and it is shown in **Table 2** and **Table 3**.

The biggest change of IOPav in the PAC/PAC group was in the 6th month, while in the control group, that was the case in the 3rd month.

Bonferroni test established a statistically significant difference in the postoperative change of IOPav. The reduction of IOPav was lesser in the Cataract group compared to the PAC/PACG group in the 1st ($p < 0.01$) and the 6th month ($p < 0.05$).

With regard to IOPst, the data from **Table 3** show that its biggest absolute and relative reduction compared to the preoperative value in the PAC/PACG group was in the 3rd month. In the Cataract group, the biggest absolute reduction was in the 6th month. The data on the relative change of IOPst, which were positive values, show its increase compared to the preoperative value which, at first glance, seems incorrect,

**Table 3.** Descriptive data for the absolute and relative postoperative changes of IOPst
***Tabela 3.*** *Deskriptivni podaci za apsolutnu i relativnu postoperativnu promenu kratkoročnih fluktuacija intraokularnog pritiska*

| | Δ IOPst 1 mth/Δ *IOPst 1. mesec* M ± SD (mmHg) (%) | Δ IOPst 3 mth/Δ *IOPst 3. mesec* M ± SD (mmHg) (%) | Δ IOPst 6 mth/Δ *IOPst 6. mesec* M ± SD (mmHg) (%) |
|---|---|---|---|
| PAC/PACG N/*Br.* = 31 | -1.34 ± 3.46 (6.82) | -1.61 ± 3.55 (-6.31) | -1.37 ± 4.04 (25.84) |
| Cataract/*Katarakta* N/*Br.* = 31 | -0.38 ± 1.67 (4.98) | -0.42 ± 1.65 (14.85) | -0.55 ± 1.72 (2.00) |

Legend: PAC/PACG – primary angle closure/primary angle-closure glaucoma; Δ IOPst - postoperative changes of the short-term intraocular pressure fluctuations; M - mean; SD - standard deviation
*Legenda: PAC/PACG – primarno zatvarajući ugao/primarni glaukom zatvarajućeg ugla; Δ IOPst – postoperativna promena kratkoročnih fluktuacija intraokularnog pritiska; M – prosek; SD – standardna devijacija*

**Table 4.** Correlation between the preoperative and postoperative mean intraocular pressure and short-term intraocular pressure fluctuations
***Tabela 4.*** *Korelacija preoperativnog prosečnog intraokularnog pritiska i kratkoročnih fluktacija intraokularnog pritiska sa njihovom postoperativnom promenom*

| | | | | |
|---|---|---|---|---|
| PAC/PACG (N/*Br.* = 31) | | | | |
| | | Δ IOPav 1 mth/Δ *IOPav 1. mesec* | Δ IOPav 3 mth/Δ *IOPav 3. mesec* | Δ IOPav 6 mth/Δ *IOPav 6. mesec* |
| IOPav preop. *IOPav preop.* | $r_s$ | -0.479** | -0.576** | -0.557** |
| | p | 0.006 | 0.001 | 0.001 |
| | | Δ IOPst 1 mth/Δ *IOPst 1. mesec* | Δ IOPst 3 mth/Δ *IOPst 3. mesec* | Δ IOPst 6 mth/Δ *IOPst 6. mesec* |
| IOPst preop. *IOPst preop.* | $r_s$ | -0.825** | -0.790** | -0.875** |
| | p | 0.000 | 0.000 | 0.000 |
| Cataract/*Katarakta* (N/*Br.* = 31) | | | | |
| | | Δ IOPav 1 mth/Δ *IOPav 1. mesec* | Δ IOPav 3 mth/Δ *IOPav 3. mesec* | Δ IOPav 6 mth/Δ *IOPav 6. mesec* |
| IOPav preop. *IOPav preop.* | $r_s$ | -0.321 | -0.394* | -0.378* |
| | p | 0.078 | 0.028 | 0.036 |
| | | Δ IOPst 1 mth/Δ *IOPst 1. mesec* | Δ IOPst 3 mth/Δ *IOPst 3. mesec* | Δ IOPst 6 mth/Δ *IOPst 6. mesec* |
| IOPst preop. *IOPst preop.* | $r_s$ | -0.600** | -0.674** | -0.707** |
| | p | 0.000 | 0.000 | 0.000 |

Legend: PAC/PACG – primary angle closure/primary angle-closure glaucoma; Δ IOPav - postoperative changes of the mean intraocular pressure; Δ IOPst - postoperative changes of the short-term intraocular pressure fluctuations; $r_s$ - Spearman correlation coefficient; p – statistically significant value; *$p < 0.05$; **$p < 0.01$
*Legenda: PAC/PACG – primarno zatvarajući ugao/primarni glaukom zatvarajućeg ugla; Δ IOPav – postoperativna promena prosečnog intraokularnog pritiska; Δ IOPst – postoperativna promena kratkoročnih fluktuacija intraokularnog pritiska;* $r_s$ *– Spirmanov koeficijent korelacije; p – statistička značajnost; *p < 0,05; **p < 0,01*

since IOPst has reduced postoperatively. This phenomenon is explained by the deviated values of IOPst registered in some patients.

Kruskal-Wallis and Bonferroni's tests established that there were no statistically significant differences between the research groups for the absolute change of IOPst.

Spearman's correlation test in both groups established a negative correlation between the preoperative and postoperative IOPav and IOPst **(Table 4)**. In the PAC/PACG group, there was a moderately strong correlation for the IOPav and distinctly strong for the IOPst. In the Cataract group, there was a weak correlation for the IOPav and a strong for the IOPst.

The postoperative antiglaucoma therapy was changed compared to the preoperative period in terms of the number and the types of medications. At the end of the research, there was a reduction of 18.4% in the number of medications compared to the preoperative period, from average number of 2.45 medication preoperatively to average number of 2.0 medication at the 6th month.

## Discussion

In our research, there was no significant difference between the groups in regard to gender and age distribution, but there were slightly more female patients. Postoperatively, in both groups, there was a statistically and clinically significant improvement in the BCVA.

In order to get a proper insight into the effects of cataract surgery on the level of IOP and in order to avoid a "carryover" effect, it would have been ideal if there had been a preoperative "washout" period for antiglaucoma medications. Another option would be to keep the patients on preoperative therapy by type, number and treatment regimen after surgery. Guided by the ethical principles of clinical studies and postulates, primarily the postulate "Primum non nocere!", none of the above options could have been applied in our research and the postoperative antiglaucoma therapy was altered in the way described above.

As a biological phenomenon, the intraocular pressure is not fixed, but it changes during the 24-hour cycle and from one visit to another [14] and it is clear that one measurement of IOP within the regular working hours is a poor replacement for a circadian IOP profile of glaucoma patients [15]. The significance of IOP fluctuations is an important, but still an insufficiently studied risk factor for the occurrence and/or progression of glaucoma. This is evident from a growing number of studies in recent years dealing with these issues. With an objective to collect the most accurate data on IOP fluctuations, thanks to the development of new technologies, various extraocular and intraocular devices have been designed with integrated pressure sensors. Due to a number of shortcomings such as inconvenience, discomfort they cause, data presentation and a high price, these devices are not applicable in daily clinical practice and for now, they remain reserved only for research projects.

Recent studies on these issues come from highly developed countries and centres with access to new technologies such as Triggerfish contact-lens sensor, contact or non-contact tonometers for personal use (Icare HOME tonometer, Tono-Pen, Corvis ST, Ocular Response Analyzer, etc.) and less often, tonometers for intraocular application (EYEMATE) [16–18]. However, in the current clinical practice, Goldmann applanation tonometer (GAT) is considered a gold standard, due to its application in the majority of clinical studies since the 70s, and because of extensive publications about its accuracy, reliability and repeatability.

The DTC test of IOP is relatively inexpensive, but impractical both for the examiner and the patient (the patients come several times a day or they are hospitalized) and as such is rarely used in everyday clinical practice [19]. Despite the impracticality to perform, for the needs of our research, DTC test included three measurements per day at 07:30, 13:30 and 19:30 using GAT, and from the obtained data, IOPav and IOPst were determined. We compared our results with previous studies that analyzed the effect of cataract surgery on IOP fluctuation, which used GAT. However, a limiting factor is that there are few published studies that can be used for comparison.

Our results show that a statistically significant change of IOPst in the PAC/PACG group was in the 1st and 3rd postoperative month, whereas the most pronounced absolute (-1.61 ± 3.55 mmHg) and relative (-6.31%) reduction was in the 3rd month **(Table 3)**. From preoperative 4.24 ± 3.67 mmHg, IOPst in the 3rd month was reduced to 2.63 ± 1.63 mmHg **(Table 1)**, which is very similar to the results of Özyol et al. [20] who prospectively studied the effect of PHACO on diurnal fluctuation of IOP in 24 medically treated patients (39 eyes) with PACG and with a previously done laser iridotomy. The IOP was measured using GAT three times a day, at 08:00, 12:00 and 14:00, preoperatively and after 3 months postoperatively. The authors found a significant reduction of IOP fluctuation from preoperative 4.6 ± 2.1 mmHg to 2.8 ± 1.5 mmHg, 3 months after surgery.

Liu et al. [21] also used DTC test preoperatively and 3 months after the cataract surgery in 29 patients with PACG and previously done laser iridotomy. The IOP was measured at 08:00, 12:00 and 16:00 using GAT. In the 3rd postoperative month, they found that there was a significant reduction in IOP fluctuation by – 1.3 ± 2.3 mmHg compared to the preoperative fluctuation of 3.3 ± 2.5 mmHg. The methodology of the study by Liu et al. describes postoperative modification in medications almost in the same way as it was done in our research (excluding pilocarpine, pausing the prostaglandin analogues and introducing a replacement therapy with CAI, or similar). They reported a significant reduction in the number of medications from 1.93 ± 1.13 preoperatively to 0.83 ± 0.89 postoperatively. Correlation analysis in both groups established a negative correlation between preoperative and postoperative IOPav and IOPst **(Table 4)**. This means that preoperatively higher IOPav can be expected to have a larger reduction postoperatively. In accordance with the above-mentioned, short-term fluctuations are postoperatively "narrower" if the preoperative range is wider.

After an extensive search of literature on Medline and PubMed, we did not find data on correlation analysis of preoperative and postoperative short-term fluctuations of IOP in patients with PAC/PACG who had a cataract surgery, which additionally contributes to the relevance of our data.

Although the main goal of our research was to analyze the IOPst, it is also necessary to report about the postoperative reduction of the IOPav. In both groups, the postoperative IOPav was significantly lower than preoperative IOPav **(Table 1)**. The biggest change of IOPav in the PAC/PACG group was in the 6th month when it was -4.14 ± 2.50 mmHg, i.e. -22.18 % **(Table 2)**. In the control group, that was the case in the 3rd month and the reduction of IOPav was - 2.44 ± 1.76 mmHg, i.e. - 16.40% **(Table 2)**.

Our results are in agreement with other researchers who analyzed the effects of PHACO on the intraocular pressure in patients with PAC/PACG. Shams and Foster [22] reported a significant reduction of IOP from preoperative 18.7 ± 7.3 mmHg to postoperative 14.1 ± 4 mmHg (reduction of - 4.5 ± 5.4 mmHg; - 24%). The results of their retrospective study point out that the reduction was more noticeable in patients with preoperatively higher IOP and the finding of PAS to over 180° of ICA.

According to the study by Pandav et al., the reduction of IOP in the 6th month in PAC group was - 2.08 mmHg (- 13.5%), and in PACG group - 2.55 mmHg (- 14.5%) [23].

A study by Traverso and Cutolo included a sample of 37 patients with PACG and 17 patients with PAC. In the PACG group, a preoperative average IOP of 22.29 ± 8.83 mmHg decreased by - 8.45 ± 8.03 mmHg (-37.9%) in the 6th month. In the PAC group, there was a reduction of IOP of - 3.1 ± 4.8 mmHg (- 20%) in the 6th month compared to the preoperative IOP of 15.50 ± 4.85 mmHg [24].

## Conclusion

The results of our research show that cataract surgery in patients with primary angle closure/primary angle-closure glaucoma resulted in a significant reduction of the average intraocular pressure, short-term intraocular pressure fluctuations, and a reduction in the number of medications.

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