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*Original Article*

# Influence of preoperative dilation time on the effect of cataract ultrasonography combined with goniostomy in patients with primary closed angle glaucoma and its clinical significance

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**Abstract:** Objective: To evaluate the impact of preoperative pupil dilation time on the outcomes of cataract ultrasonoemulsification combined with goniostomy in patients with primary angle-closure glaucoma (PACG). Methods: A retrospective analysis was conducted on 106 PACG patients who underwent cataract ultrasonoemulsification with goniostomy. Patients were divided into two groups based on pupil dilation times: group A (dilation time between 20 to 30 minutes) and group B (dilation time between 30 minutes to 1 hour). Pre- and postoperative intraocular pressure (IOP), visual acuity, pupil diameter, anterior chamber depth (ACD), and lens thickness (LT) were measured. Surgical time and cumulative dissipated energy (CDE) were also analyzed. Multivariate analysis was performed to identify independent risk factors for postoperative complications. Results: Both groups showed significant postoperative improvement in visual acuity ($P < 0.05$). Group B exhibited significantly lower postoperative IOP than group A ($P < 0.05$). There were significant increases in ACD and pupil diameter and a decrease in LT post-dilation in both groups (all $P < 0.05$). Group B showed a deeper ACD, thinner LT, and larger pupil diameter compared to group A (all $P < 0.05$). While CDE was similar between groups, operation duration was longer in group A ($P < 0.05$). Disease course > 5.5 years, preoperative IOP > 25.14 mmHg, pupil diameter before dilation < 4.895 mm, ACD before dilation < 2.105 mm, and dilation time ≤ 30 minutes were independent risk factors for postoperative complications. Conclusion: Preoperative pupil dilation time > 30 minutes leads to better surgical outcome. Several preoperative factors, including dilation time ≤ 30 minutes, are independent risk factors for postoperative complications.

**Keywords:** Dilation time, primary closed-angle glaucoma, cataract ultrasonography, goniostomy

## Introduction

Glaucoma, a prevalent neurodegenerative disease, is the second leading cause of blindness worldwide [1, 2]. It is characterized by retinal ganglion cell (RGC) degeneration and progressive damage to optic nerve axons [3]. Elevated intraocular pressure (IOP) is the primary contributor to glaucoma, leading to irreversible blindness [4]. While both primary open-angle glaucoma (POAG) and primary angle-closure glaucoma (PACG) can result in blindness, studies consistently show a higher risk of blindness associated with PACG [5, 6]. In fact, PACG patients are three times more likely to suffer severe visual acuity loss than POAG patients [7].

Pupillary blockade, a key mechanism in PACG [8], can cause sudden or intermittent increases in IOP during acute episodes or chronic asymptomatic periods, respectively. These spikes in IOP can lead to optic nerve damage and progressive visual field loss [9]. Projections suggest that by 2040, approximately 30 million individuals worldwide, predominantly in Asian populations, will be affected by PACG [10].

Persistent elevation of IOP in individuals with PACG can result in continued compression of the peripheral iris, leading to narrowing or com-

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plete closure of the anterior chamber angle. In such cases, surgical intervention is required [11]. However, researchers have proposed that ultrasound emulsification as a standalone treatment may only be suitable for some patients with POAG [12]. When ultrasound emulsification fails to adequately open the anterior chamber angle and control IOP, combining it with atrial angle dissection is recommended [13].

Achieving full dilation of the pupil is crucial for the success of this procedure [14]. An inadequately dilated pupil can complicate the operation, increasing the risk of injuries [15]. However, prolonged dilation of the pupil can also have adverse effects, with preoperative dilation time within 1 hour being considered safe [16]. Prolonged dilation may cause mechanical obstruction of the anterior chamber angle or pupillary block, disrupting the circulation of aqueous fluid and possibly triggering elevated intraocular pressure and acute glaucomatous episodes [17]. Conversely, inadequate pupil dilation may necessitate the intraoperative administration of drugs like epinephrine or norepinephrine to rapidly dilate the pupil, increasing the surgical risk and the likelihood of complications [18].

Currently, there are no standard guidelines for the optimal duration and frequency of preoperative pupil dilation in the clinical practice. Therefore, this study aims to explore the differences in surgical outcome associated with varying preoperative pupil dilation times and to assess their safety and effectiveness.

## Methods and materials

### *Patient selection*

The medical records of PACG patients who underwent cataract ultrasonoemulsification combined with atrial angle segmentation from August 2021 to February 2023 at Lanzhou Petrochemical General Hospital were retrospectively analyzed. The study was conducted strictly with the Declaration of Helsinki after obtaining permission from the Lanzhou Petrochemical General Hospital Medical Ethics Committee.

Inclusion criteria: Patients with an age of 18 years or above; Patients with PACG, unilateral ocular onset; Patients with a cataract nuclear hardness of grade II-III; Patients who underwent cataract ultrasonoemulsification combined with atrial angle separation; Patients with complete and available eye parameter examination data before and after surgery. Exclusion criteria: Patients with probable pregnancy; Patients with closed or potentially occluded anterior chamber angles; Those who had taken pupil constricting medication within 12 hours of surgery; Patients with preoperative inflammation or infection in the eye; and those with incomplete case data.

After applying these inclusion and exclusion criteria, this study finally collected the medical records of 106 PACG patients. Group A included 48 patients whose pupil dilation time ranged 20 to 30 minutes (including 20 min and 30 min), and Group B included 58 patients with a pupil dilation time of 30 minutes -1 hour (excluding 30 min and 1 hour). The collection process is shown in **Figure 1**.

### *Data extraction*

The basic- and surgical-related information of patients was systematically extracted from patient charts for analysis, including age, disease duration, gender, affected eye, visual acuity and intraocular pressure (IOP) before and after surgery, pupil diameter before and after dilation, anterior chamber depth (ACD) before and after dilation, lens thickness (LT) before and after dilation, time of surgery, and cumulative dissipated energy (CDE).

### *Observational outcomes*

*Primary outcomes:* The preoperative and postoperative IOP and vision were measured in the two groups of patients. The pupil diameter, anterior chamber depth (ACD), and lens thickness (LT) before and after pupil dilation were statistically compared between the two groups.

*Secondary outcomes:* The differences in surgery time and cumulative dissipated energy (CDE) between the two groups were compared. Independent risk factors for postoperative complications were analyzed using univariate and multivariate analyses.

### *Statistical methods*

Statistical analyses were performed using SPSS 25.0 (SPSS, Chicago, IL). Continuous vari-

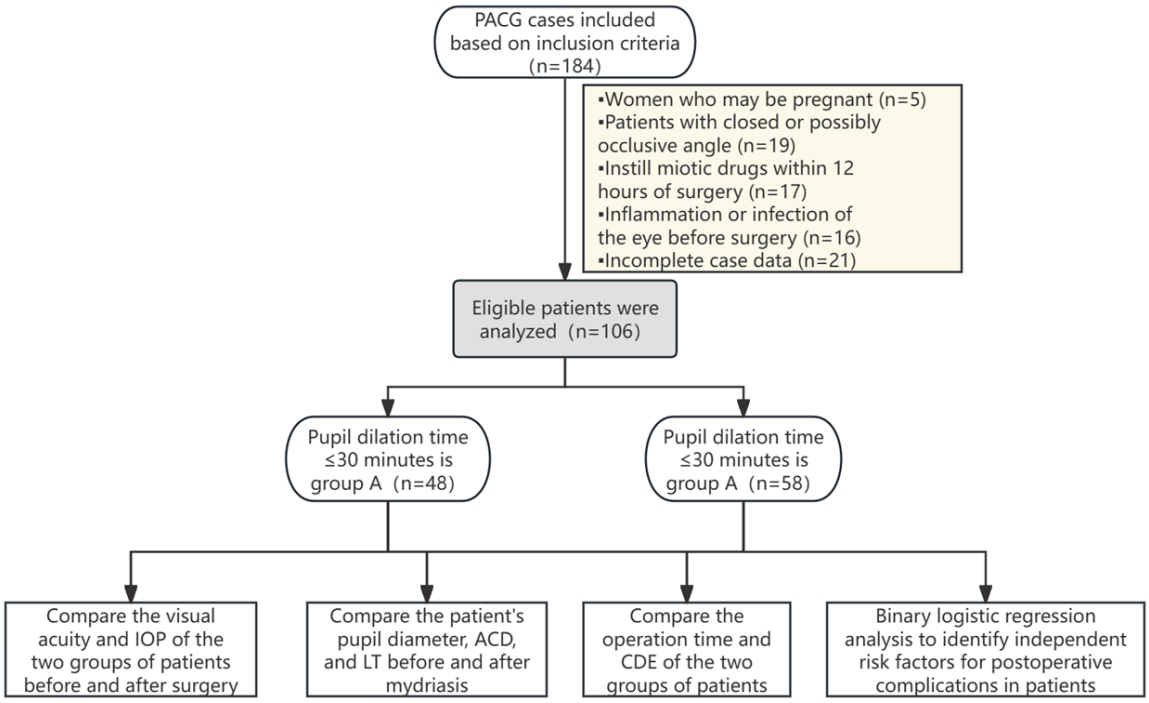


**Figure 1.** Research flow chart.

**Table 1.** Basic information

| | Group A (n=48) | Group B (n=58) | $t/\chi^2$ | P |
|---|---|---|---|---|
| Number of eyes | 48 | 58 | | |
| Age (years) | 68.33±4.87 | 68.16±4.56 | 0.185 | 0.853 |
| Disease Course (months) | 5.21±0.87 | 5.48±0.98 | 1.485 | 0.141 |
| Gender (male/female) | 20/28 | 21/37 | 0.330 | 0.566 |
| Affected eye (left eye/right eye) | 16/32 | 22/36 | 0.241 | 0.623 |
| Preoperative IOP (mmHg) | 25.12±2.14 | 25.56±1.59 | 1.213 | 0.228 |
| Preoperative visual acuity | 0.53±0.23 | 0.54±0.20 | 0.239 | 0.811 |
| Pupil diameter before dilation (mm) | 4.94±0.09 | 4.93±0.11 | 0.505 | 0.615 |
| ACD before dilation (mm) | 2.10±0.08 | 2.12±0.08 | 1.281 | 0.203 |
| LT before dilation (mm) | 5.18±0.37 | 5.21±0.42 | 0.368 | 0.714 |

IOP: Intraocular Pressure; ACD: anterior chamber depth; LT: lens thickness.

ables that conformed to a normal distribution were expressed as mean ± standard deviation; for intragroup before-after comparison, paired sample t test was used, and for between-group comparisons, the independent sample t test was used. Categorical variables (n, %) were compared using the $\chi^2$ test. Risk factors for developing postoperative complications were identified using binary logistic regression analysis. The ability of risk factors in predicting complications was assessed using the Receiver Operating Characteristic (ROC) curve. A value of $P < 0.05$ was considered significant.

## Results

### *Analysis of basic information of the patient*

The basic data of the patients, as shown in **Table 1**, shows no significant differences between the two groups in terms of age, disease course, gender, affected eye, preoperative IPO, preoperative visual acuity, pupil diam-

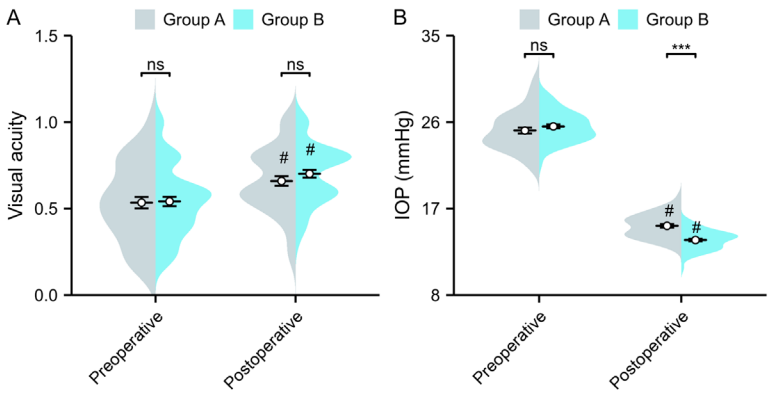


**Figure 2.** Improvement in visual acuity (A) and IPO (B) before and after surgery. ***, P < 0.001; #, P < 0.05, compare with pre-operative level. IOP: Intraocular Pressure.

eter before dilation, ACD before dilation, or LT before dilation (all P > 0.05).

*Improvements in visual acuity and IOP*

Both groups exhibited significant improvement in visual acuity after operation (all P < 0.001). However, there was no significant difference in postoperative visual acuity between the two groups (P=0.256). Both groups showed a significant decrease in postoperative IOP after operation (P < 0.001), and the postoperative IOP in group B was significantly lower than that in group A (P < 0.001). See **Figure 2**.

*Changes in LT, ACD, and pupil diameter before and after pupil dilation*

Before dilation, there was no statistical difference in the LT, ACD, or pupil diameter between the two groups (P=0.714, P=0.203, P=0.615). However, post-dilation measurements revealed significant differences: the pupil diameter and ACD were significantly greater in Group B compared to Group A (P < 0.001), while the LT was significantly thinner in Group B than in Group A (P < 0.001). See **Figure 3**.

*Comparison of operation duration and CDE between the two groups*

There was no statistical difference in the CDE between the two groups of patients (P=0.479). However, the duration of surgery in group B was significantly shorter than that in group A (P < 0.001), as shown in **Figure 4**.

*Analysis of the occurrence of postoperative complications in patients and influencing factors*

During the postoperative three months, there were 9 cases of high IOP, 7 cases of corneal edema, 5 cases of anterior chamber bleeding, 2 cases of choroidal detachment, with a total of 23 cases of postoperative complications. Univariate analysis indicated significant differences in several factors between patients who developed complications and those who did not. These factors include age, disease course, preoperative IPO, pupil diameter before dilation, ACD before dilation, LT before dilation, and dilation time (**Figure 5**).

*Predictive power of the screened factors for postoperative complications in patients*

We tested the ability of age, disease course, preoperative IPO, pre-dilatation pupil diameter, pre-dilatation ACD, and pre-dilatation LT to predict postoperative complications in patients by plotting ROC curves. We found that the AUCs of age, disease duration, preoperative IPO, pre-dilatation pupil diameter, pre-dilatation ACD, and pre-dilatation LT were all greater than 0.500, indicating certain degree of predictive ability. The results are shown in **Figure 6** and **Table 2**.

*Multifactorial analysis*

We transformed age, disease duration, preoperative IPO, pupil diameter before dilation, ACD before dilation, and LT into dichotomous variables using the cutoff value in the table. Multifactorial analysis on these indexes with statistical significance in the univariate analysis found that disease course > 5.5 months, preoperative IPO > 25.140 mmHg, pre-dilation pupil diameter < 4.895 mm, pre-dilation ACD < 2.105 mm, and pupil dilation time ≤ 30 min were independent risk factors for postoperative complications, and the results are shown in **Figure 7**.

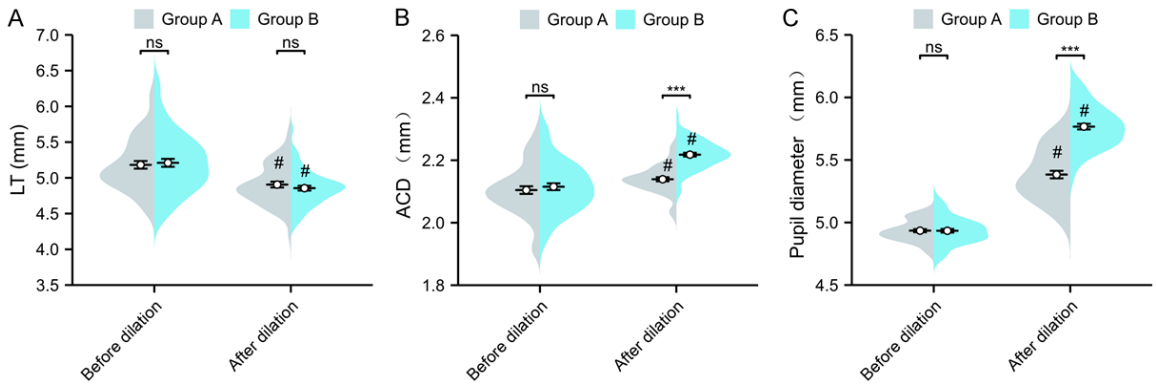


**Figure 3.** Changes in pupil diameter (A), ACD (B), and LT (C) before and after pupil dilation. ***, P < 0.001; #, P < 0.05, compared to before dilation. ACD: anterior chamber depth; LT: lens thickness.

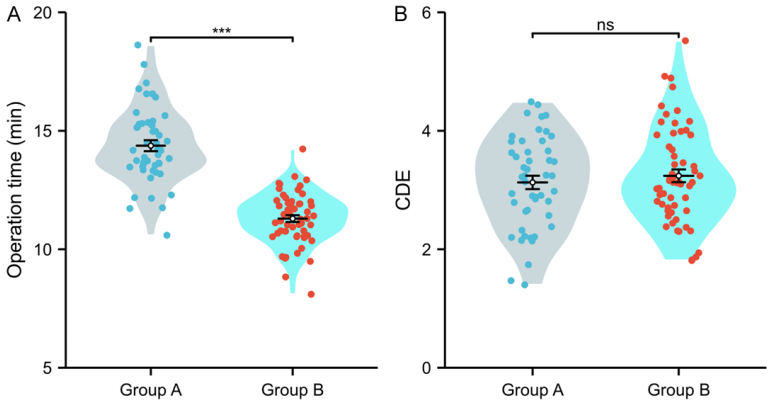


**Figure 4.** Comparison of operative time (A) and CDE (B) in two groups of patients. ***, P < 0.001. CDE: cumulative dissipated energy.

## Discussion

Adequate pupil dilation is essential for smooth operation; however, it can impede aqueous humor outflow through the trabecular meshwork channel, potentially triggering acute glaucoma attacks [19]. Previous reports have documented acute episodes in primary angle-closure glaucoma (PACG) patients following pupil dilation. PACG patients typically exhibit shallow anterior chambers, narrow angles, and elevated posterior chamber pressure. In our study, both groups showed significantly increased anterior chamber depths (ACD), and decreased lens thickness (LT) post-dilation than pre-dilation. Moreover, post-dilation measurements showed that ACD was significantly deeper, and LT was thinner in Group B compared to Group A. The thinner LT in group B likely contributed to a more pronounced increase in anterior chamber volume, explaining the deeper ACD. Adewara et al. [20] observed a negative correlation between ACD and LT in glaucoma patients, reinforcing our findings. Additionally, our study revealed a significantly larger pupil diameter in group B post-dilation compared to group A, indicating that prolonged dilation resulted in a larger pupil size. This prolonged dilation led to a more extensive posterior displacement of the ciliary-iris-lens septum, further deepening the ACD in group B patients [21]. However, Autrata et al. [22] studied 40 cataract surgery patients and found that mydriasis had no significant effect on axial length, LT and corneal parameters, but significantly increased central corneal thickness and ACD.

In our study, both groups showed significant improvement in postoperative visual acuity compared to the preoperative levels. However, there was no significant difference in postoperative visual acuity between the two groups, indicating that the duration of dilation did not significantly impact visual outcomes. This could be attributed to the primary goals of glaucoma surgery, which focus on controlling intraocular pressure and protecting optic nerve - outcomes that are mainly independent of dilation duration. Visual impairment in glaucoma primarily stems from optic nerve damage, which is not directly influenced by dilation duration [23, 24]. Schulz et al. [25] similarly found that pupil dilation had no significant effect on postoperative

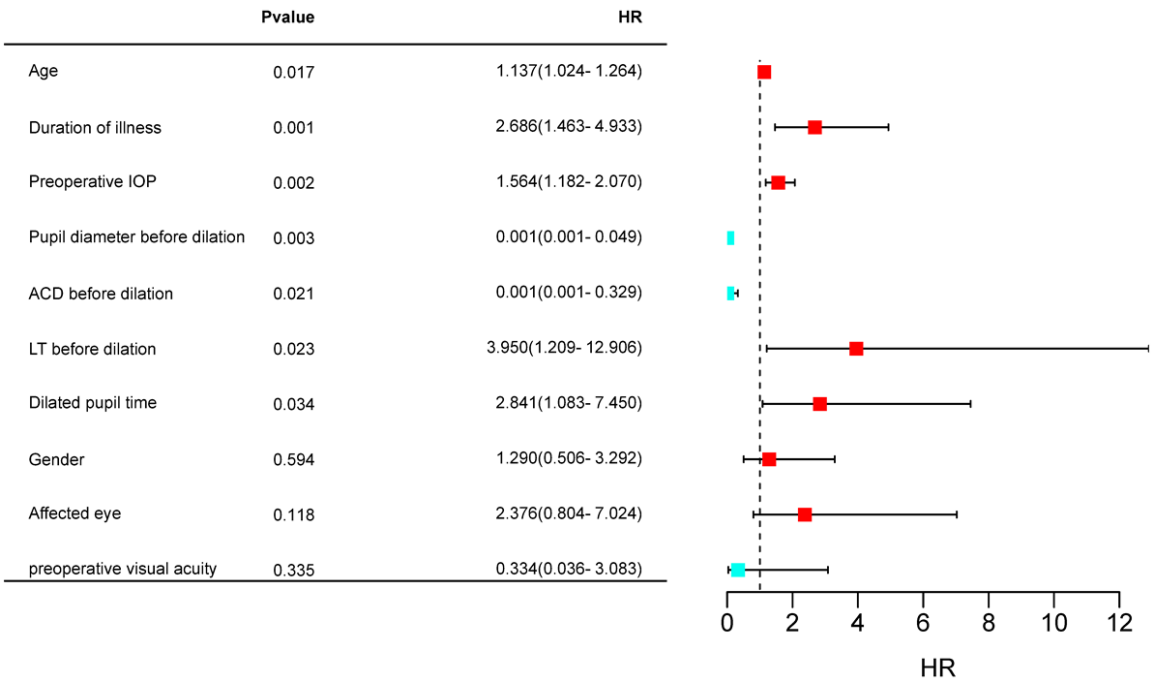


**Figure 5.** Forest plot of single factor analysis that may affect patients' postoperative complications.

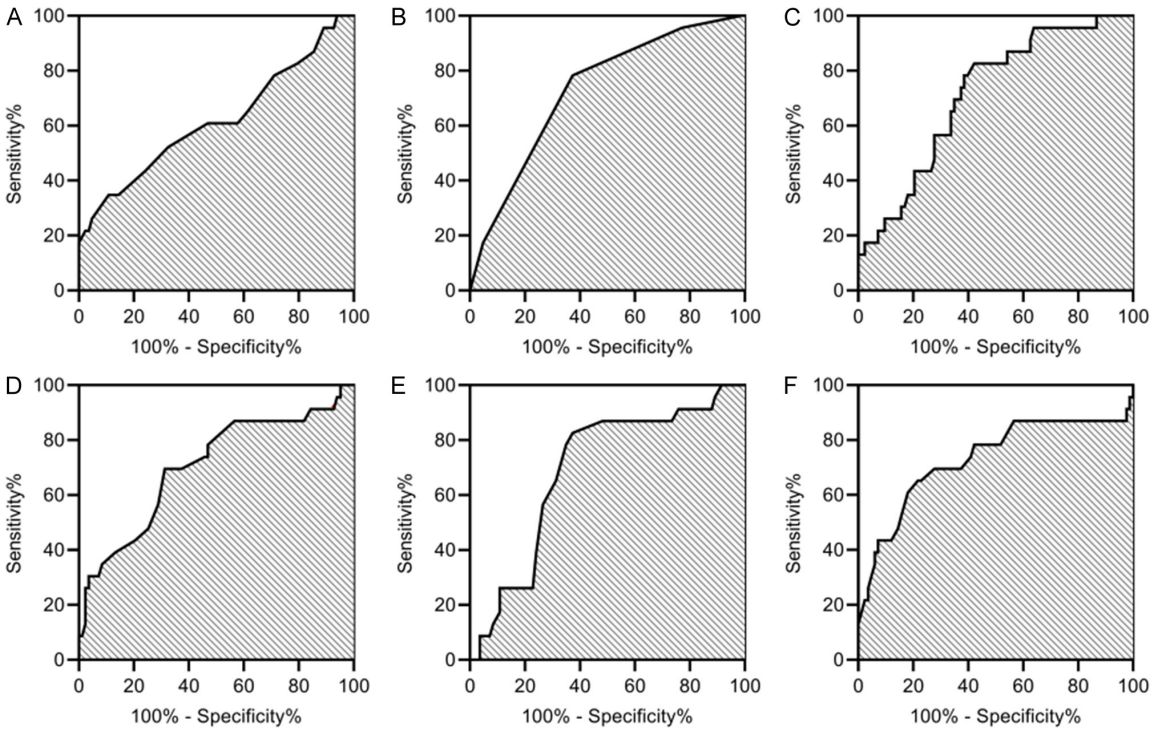


**Figure 6.** ROC curves for various factors in predicting postoperative complications. A. Age; B. Disease course; C. Preoperative IPO; D. Pupil diameter before dilation; E. ACD before dilation; F. LT before dilation.

visual acuity in cataract patients, although facilitated the preoperative process. Katz et al. [26] found in their study that patients who underwent combined cataract and glaucoma surgery with pupil dilation had slightly higher IOP 6 months after surgery, but there was no

**Table 2.** ROC results

| | Cut-off | Sensitivity | Specificity | AUC |
|---|---|---|---|---|
| Age | > 72.500 | 34.78% | 89.16% | 0.617 |
| Disease course | > 5.500 | 78.26% | 62.65% | 0.730 |
| Preoperative IPO | > 25.140 | 82.61% | 57.83% | 0.712 |
| Pupil diameter before dilation | < 4.895 | 69.57% | 68.67% | 0.705 |
| ACD before dilation | < 2.105 | 82.61% | 62.65% | 0.692 |
| LT before dilation | > 4.995 | 86.96% | 39.76% | 0.640 |

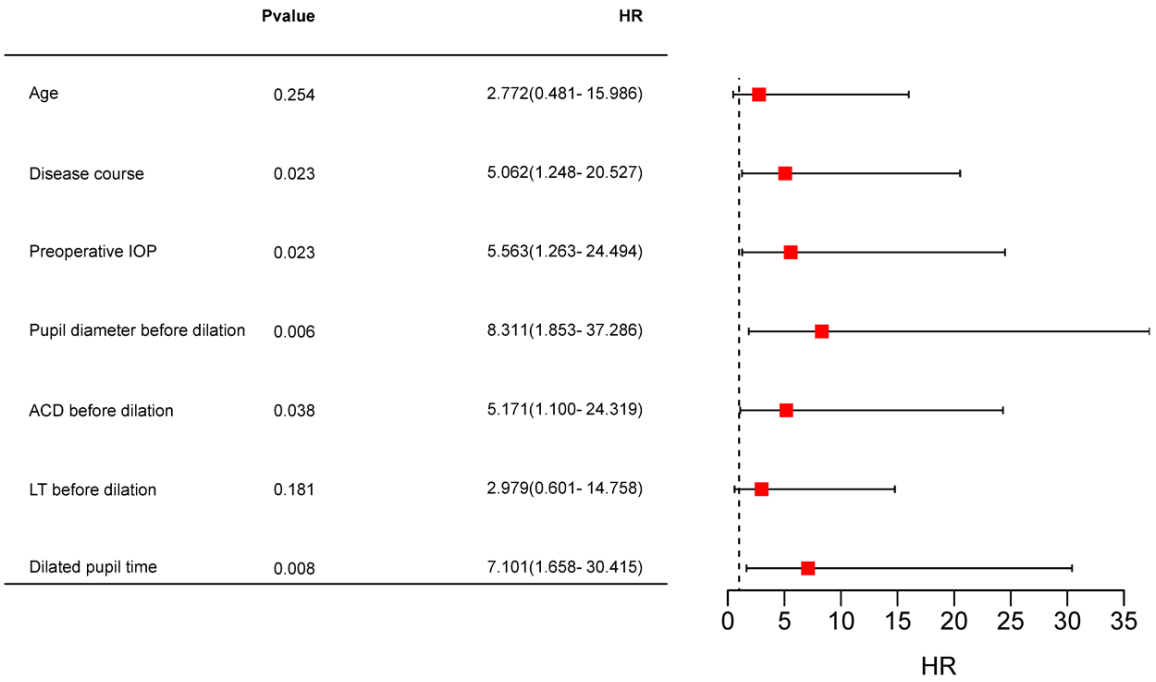


**Figure 7.** Forest plot of independent risk factors affecting patients' postoperative complications through multi-factor analysis.

significant difference in best-corrected visual acuity between the two groups, indicating that pupil dilation does not significantly impact final visual recovery following surgery. In our study, however, group B exhibited significantly lower postoperative IOP than group A, indicating a more pronounced IOP drop with prolonged dilation. This could be attributed to more extensive pupil dilation in group B, providing surgeons with a clearer view of intraocular structures, thereby enhancing surgical precision and outcome [27].

Patients undergoing cataract ultrasonic emulsification combined with goniostomy for glaucoma generally experience improved visual acuity due to reduced IOP but are also susceptible to postoperative complications. Within three months post-surgery, 9 cases of high IOP, 7 cases of corneal edema, 5 cases of anterior chamber bleeding, and 2 cases of choroidal detachment were reported. Univariate analysis identified age, disease duration, preoperative IOP, pupil diameter before dilation, ACD before dilation, LT before dilation, and dilation time as potential influential factors for postoperative complications. ROC curves demonstrated that the AUCs for these factors were all greater than 0.5, indicating their potential predictive value. Multifactorial analysis through binary logistic regression identified disease course > 5.5 months, preoperative IOP > 25.140 mmHg, pupil diameter before dilation < 4.895 mm, ACD before dilation < 2.105 mm, and dilation time ≤ 30 minutes as independent risk factors for postoperative complications. Several stud-

ies have suggested that the variability in postoperative complications may also be related to factors such as physician experience, physician age, surgical technique, instrument manipulation, and patient-specific anatomic variations [28, 29]. These findings are of great significance for clinicians to assess patients' surgical risks before surgery, optimize surgical plans, and mitigate potential complications. Identifying these independent risk factors enables medical team to conduct more precise risk stratification before surgery and implement appropriate measures.

*Shortcomings and prospects*

This study has certain limitations. First, as a retrospective study, it may have confounding factors interfering with the results, leading to potential errors in interpretation. The study was constrained by the time frame of data collection, which did not allow for the long-term assessment of treatment effects on patients. The study did not include data on postoperative visual fields or optic nerve fiber layers. Also, surgical outcomes can vary significantly based on the expertise and experience of the surgeon, which was not controlled for in this study. Finally, we conducted multifactor analysis with many independent variables, which did not comply with the one in ten rule. Future research could employ a prospective design, increase the sample size, extend the follow-up duration, and include a broader range of outcome measures.

## Conclusion

Preoperative pupil dilation time > 30 minutes results in better surgical and clinical outcomes. Disease course > 5.5 months, preoperative IPO > 25.140 mmHg, pupil diameter < 4.895 mm before dilation, ACD < 2.105 mm before pupil dilation, and pupil dilation time ≤ 30 min were independent risk factors for postoperative complications in PACG patients.

## Disclosure of conflict of interest

None.

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