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ORIGINAL RESEARCH

Surgical Outcomes of Cataract Surgery Following Rapid Glycemic Control During Preoperative Period

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Purpose: To evaluate the effects of rapid preoperative glycemic control on outcomes of cataract surgery for type 2 diabetes patients with high HbA1c levels.

Methods: The medical data of consecutive cohort patients with type 2 diabetes who underwent cataract surgery were respectively reviewed between January 2023 and May 2024. The rapid control group consisted of 152 patients (222 eyes) with HbA1c >9.0% following rapid glycemic control (average duration: 17.3 ± 6.6 days), and the basic control group consisted of 111 patients (162 eyes) with HbA1c <7.0%. Complications and visual outcomes were analyzed between the two groups during the 6-month postoperative follow-up.

Results: Macular edema and vitreous hemorrhage were the main postoperative complications in rapid control group (11.7%) and basic control group (4.9%) ($P = 0.021$). Linear Mixed-effects Models analysis showed that rapid glycemic correction (Odds ratio [OR] = 6.525, 95% confidence interval [CI] = 2.927–14.547, $P < 0.001$) and moderate to severe non-proliferative diabetic retinopathy (OR = 0.119, 95% CI = 0.054–0.263, $P < 0.001$) were the main risk factors of complications. However, only 3.8% of patients with timely intervention for diabetic retinopathy developed severe complications in rapid control group ($P = 0.019$). Besides, other complications including endophthalmitis, hyphema or incision leakage were not observed in rapid control group. At the final follow-up, the average best correction visual acuity in rapid control group was 0.30 ± 0.32 logMAR, with significant improvement compared with 1.26 ± 0.74 logMAR before surgery ($P < 0.0001$).

Conclusion: It seems to be unnecessary to prolong the duration of glycemic control before cataract surgery from safety and effectiveness. Timely intervention may prevent the severe complications of diabetic retinopathy after cataract surgery following rapid glycemic control.

Keywords: type 2 diabetes mellitus, HbA1c, rapid glycemic control, cataract surgery, diabetic retinopathy, complications

Introduction

Type 2 diabetes mellitus is a global health concern associated with many ocular complications, and it affects millions of people in China.[1] Cataract, a highly prevalent disease in patients with type 2 diabetes mellitus, remains the leading cause of blindness worldwide.[2] Although modern surgical techniques have improved advancements overall, the performance of cataract surgery on type 2 diabetes patients with high hyperglycemia is still associated with a high risk,[3,4] such as infection, postoperative inflammation, and delayed wound healing.[5]

Glycemic control is the most important factor during the preoperative management of patients with type 2 diabetes undergoing cataract surgery.[6,7] Glycosylated hemoglobin (HbA1c) is a key marker that reflects the glycemic control level over the previous 3 months.[8] In accordance with international guidelines, HbA1c levels are recommended to be controlled below 7.0% prior to cataract surgery.[9] However, there are no internationally accepted guidelines specifically

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for the perioperative management of cataract patients with diabetes.[5] Decisions about the timing of cataract surgery need to consider the stage of the cataract and the degree of diabetic retinopathy (DR).[10] Rapid improvement in glycemic control can be achieved during the perioperative period for cataract surgery, but it is not precisely defined in terms of speed and time of glycemic control.[11] Previous studies have reported that rapid glycemic control for more than 3 months to achieve the target HbA1c value cannot effectively prevent the progression of DR.[3] Moreover, rapid glycemic fluctuation is reported to be associated with deterioration of retinopathy, however, glycemic variability in the development of DR still lacks a unified definition and consensus.[12] Currently, few studies reported the perioperative glycemic management of diabetes patients undergoing cataract surgery, and no internationally accepted guideline on clinical decision for perioperative glycemic control before cataract surgery.[5]

Therefore, our study retrospectively reviewed the medical records of type 2 diabetes patients with high HbA1c levels who underwent cataract surgery following short-term rapid glycemic control during preoperative period to assess the outcomes of cataract surgery and further provide guidance for perioperative glycemic control before cataract surgery in patients with type 2 diabetes.

Materials and Methods

Patient Selection

The study was approved by the ethics committee of Qingdao Eye Hospital (2024–15) and conducted in accordance with the principles of the Declaration of Helsinki. The medical records of consecutive cohort type 2 diabetes patients with HbA1c levels >9.0% or <7.0% who underwent cataract surgery at Qingdao Eye Hospital between January 2023 and May 2024 were retrospectively reviewed. Patients with a history of corneal diseases, uveitis, high myopia, age-related macular degeneration, retinal vascular disease caused by hypertension or other diseases, and postoperative follow-up of less than 6 months were excluded. The enrolled patients were divided into two groups: the rapid glycemic control group, which consisted of 152 patients (222 eyes) with HbA1c >9.0% within 3 months before surgery, and the basic control group, which consisted of 111 patients (162 eyes) with HbA1c <7.0%.

Perioperative Management

Before surgery, gatifloxacin eye gel (Diyou®, 3 mg/g; Shenyang Xingqi Pharmaceutical Co., Shenyang, China) was administered four times a day for three consecutive days. Prior to surgery, topical 5% povidone-iodine eyedrop was applied to the ocular surface, conjunctival sac. During surgery, 750 mg cefuroxime (Esseti Farmaceutici S.r.l., Noble, Italy) was dissolved in 500 mL balanced salt solution (BSS, Shenyang Xingqi, Shenyang, Liaoning, China), and the concentration (1500 μg/mL) of the mixed solution was 45% of the European Society of Cataract and Refractive Surgeons standard (3300 μg/mL).[13]

After surgery, tobramycin-dexamethasone eye ointment (TobraDex®, 0.3% tobramycin and 0.1% dexamethasone; S. A. Alcon Couvreur N. V., Puurs, Belgium) was administered once per night for two weeks. Bromfenac sodium eye drops (BRONUCK®, 1 mg/g; Senju, Osaka, Japan) was administered twice a day for three weeks, and prednisolone acetate ophthalmic suspension (Pred Forte®, 10 mg/g; Allergan Pharmaceuticals, Westport, Ireland) was administered four times a day for four weeks.

Cataract Surgery

All cataract surgeries were performed by two experienced cataract surgeons. Each patient received the standard surgical procedure successfully, and monofocal intraocular lens were implanted in all patients during the surgery.

Data Collection

The recorded medical data included sex, age, duration of diabetes, pre- and postoperative best corrected visual acuity (BCVA), random blood glucose, HbA1c within 3 months before surgery, preoperative degree of DR, duration of phacoemulsification, cumulative dissipated energy, intra- and postoperative complications and treatment for DR. BCVA was converted into the logarithm of the minimum angle of resolution (logMAR) unit.

Glycemic Control and Classification of DR

HbA1c and random glycemic values were measured before cataract surgery, and the glycemic levels in patients with HbA1c >9.0% were further controlled in the Professional Endocrinology Department before cataract surgery. Endocrinologists adjusted the dosage of hypoglycemic drugs and glycemic levels of patients were monitored at different times every day, including fasting blood glucose levels and blood glucose levels 2 hours after meals. The random blood glucose should be 4–12 mmol/L.[9] The degree of DR could not be determined before surgery due to lens opacity, it should be further evaluated by a professional fundus physician at one week after cataract surgery. DR was graded on a 5-stage severity scale, namely, none, mild, moderate and severe non-proliferative DR (NPDR), or proliferative DR, according to international clinical classification systems.[14] Follow-up was conducted at 1 week, 1 month, 3 months, and 6 months after surgery, and appropriate treatment will be given based on the degree of DR.

Statistical Analyses

SPSS software (version 24.0; SPSS, Inc. Chicago, IL, United States) was used for the statistical analyses. The data are presented as percentages or means ± standard deviations (SD), and normality of the data was assessed by the Shapiro–Wilk test. Continuous variables were compared between the two groups via independent sample *t* tests, paired *t* tests or Mann–Whitney *U*-tests. Categorical variables were compared between the two groups vis chi-square tests, Fisher's exact tests or chi-square continuity correction tests. To avoid the non independence of binocular data from the same patient, linear Mixed-effects Models with patient numbers as random intercept were used to analyze the risk factors for complications of DR. Statistical significance was defined as $P < 0.05$.

Results

The demographic and clinical characteristics of the study population are summarized in Table 1. There were no significant differences in age, sex, or duration of diabetes between the two groups ($P > 0.05$). However, the mean

Table 1 Basic Characteristics of Study Population

	Rapid Control (n = 222)	Basic Control (n = 162)	*P* value
Sex (man) (n, %)	81 (53.3)	63 (56.8)	0.631[b]
Age, Y (mean ±SD) (n, %)	65.3 ± 12.1	65.7 ± 8.7	0.605[a]
< 50	22 (14.5)	0 (0)	
50 – 60	36 (23.7)	41 (36.9)	
> 60	94 (61.8)	70 (63.1)	
Duration of diabetes, y (mean ±SD) (n, %)	11.5 ± 7.2	11.1 ± 7.7	0.611[a]
< 5	43 (28.3)	35 (31.5)	
5–10	39 (25.7)	37 (33.3)	
> 10	70 (46.1)	39 (35.1)	
Duration of glycemic control (d)	17.3 ± 6.6	/	
HbA1c values, % (mean ± SD)	9.9 ± 0.9	6.4 ± 1.5	< 0.001[a]
Immediate glycemic values, mmol/L (mean ± SD)			
Before control	16.7 ± 4.1	/	
After control	8.6 ± 1.9	8.3 ± 2.3	0.587[a]
Degree of DR identified at 1 w post-surgery (n, %)			< 0.001[b]
No	69 (31.1)	87 (53.7)	
Mild NPDR	63 (28.4)	41 (25.3)	
Moderate NPDR	61 (27.4)	28 (17.3)	
Severe NPDR	29 (13.1)	6 (3.7)	

(*Continued*)

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Table 1 (Continued).

	Rapid Control (n = 222)	Basic Control (n = 162)	*P* value
Retinal photocoagulation (n, %)			0.333[b]
Before surgery	35 (15.8)	21 (13.0)	
In the early postoperative period	21 (9.5)	13 (8.0)	
Energy and time of intraoperative phacoemulsification (mean ± SD)			
Phaco time, second	52.08 ± 28.73	53.12 ± 24.31	0.384[a]
Phaco energy, %	9.54 ± 3.93	9.13± 2.98	0.107[a]

Notes: [a]Independent samples *t*-test, [b]Chi-square tests, *P* value < 0.05 is considered statistically significant.
Abbreviations: y, year; w, week; d, days; DR, diabetic retinopathy; NPDR, non-proliferative diabetic retinopathy.

value of HbA1c in the rapid control group was 9.9% ± 0.9, which was significantly higher than the value of 6.4% ± 1.5 in the basic control group ($P < 0.001$). The mean random glycemic value before glycemic control in the rapid control group was 16.7 ± 4.1 mmol/L, and it decreased to 8.6 ± 1.9 mmol/L before cataract surgery following rapid glycemic control, which had no significantly different from the 8.3 ± 2.3 mmol/L in the basic control group ($P = 0.587$). The percentage of patients with moderate to severe NPDR in the rapid control group was 40.5% (90/222), which was significantly higher than the 21.0% (34/162) in the basic control group ($P < 0.001$). A total of 25.3% (56/222) and 21.0% (34/162) of the patients in the rapid and basic control groups timely underwent retinal photocoagulation before surgery and in the early postoperative period, respectively ($P = 0.333$).

During the operation and after surgery, no cases with capsule rupture, hemorrhage, incision leakage, or endophthalmitis were observed in either the rapid or basic control groups; 0.9% (2/222) of the patients in the rapid control group were found to have corneal epithelial defects, but this incidence was not significantly different compared to that in the basic control group (0%; 0/162; $P = 1.000$) (Table 2). Diabetic macular edema (DME) and vitreous hemorrhage were observed in 11.7% (26/222) of patients in the rapid control group during the subsequent follow-up, which was much higher than the 4.9% (8/162) reported in the basic control group ($P = 0.021$) (Table 2). Additionally, 65.4% (17/26) and 100% (6/6) of complications in the rapid and basic control groups occurred within 3 months post-surgery, with average time of 3.6 ±1.9 and 3.3 ± 2.0 months, respectively ($P = 0.15$). Mixed-effects models analysis further revealed that the following risk factors for complications of DR were rapid glycemic control (Odds ratio [OR] = 6.525, 95% confidence interval [CI] = 2.927–14.547, $P < 0.001$, and moderate to severe NPDR (OR = 0.119, 95% CI = 0.054–0.263, $P < 0.001$) (Table 3).

Table 2 Distribution of Complications in the Rapid and Basic Control Groups

Intraoperative and Postoperative Complications	Rapid Control (n = 222), n (%)	Basic Control (n = 162), n (%)	*P* value
Endophthalmitis	0 (0)	0 (0)	/
Corneal epithelial defects	2 (0.9)	0 (0)	1.000[c]
Capsule rupture	0 (0)	0 (0)	/
Incision leakage	0 (0)	0 (0)	/
Hyphema	0 (0)	0 (0)	/
Complications associated with retinopathy			0.021[b]
DME	20 (9.0)	6 (3.7)	
Vitreous hemorrhage	6 (2.7)	2 (1.2)	

Notes: [c]Fisher's exact tests, [b]Chi-square tests, *P* value < 0.05 is considered statistically significant.
Abbreviation: DME, diabetic macular edema.

Table 3 Analysis of Risk Factors Associated with Postoperative Complications of DR

Risk Factors	No. of Patients (%)	OR	95% CI	*P* value[e]
Sex (man)	6.9	1.422	0.645–3.134	0.382
Age > 60 years	7.4	0.977	0.941 –1.014	0.218
Rapid glycemic correction	11.7	6.525	2.927–14.547	<0.001
Moderate to severe NPDR	22.3	0.119	0.054–0.263	<0.001
Duration of diabetes > 10 years	17.0	1.000	0.945–1.059	0.999
Preexisting untreated for DR	9.3	1.384	0.513–3.732	0.520

Notes: [e]Linear Mixed-effects Models, *P* value < 0.05 is considered statistically significant.
Abbreviations: NPDR, non-proliferative diabetic retinopathy; DR, diabetic retinopathy.

Table 4 Comparison of the Incidence of Complications in the Two Groups of Patients with Early Intervention and Without Intervention for DR

	Rapid Control		*P* value	Basic Control		*P* value
	Complications of DR			Complications of DR		
	No, n (%)	Yes, n (%)		No, n (%)	Yes, n (%)	
With intervention	55 (24.8%)	1 (0.5%)	0.019[d]	32 (19.8%)	2 (1.2%)	1.000[d]
Without intervention	141 (63.5%)	25 (11.3%)		122 (75.3%)	6 (4.9%)	

Notes: [d]Chi-square continuity correction tests, *P* value < 0.05 is considered statistically significant.
Abbreviation: DR, diabetic retinopathy.

In the rapid control group, 56 (25.3%) and 34 (21.0%) of patients underwent retinal photocoagulation before surgery and in the early postoperative period, and only 1 (0.5%) of patients with intervention developed complication of DR during the follow-up, comparing with 25 (11.3%) of patients without intervention ($P = 0.019$) (Table 4).

The mean BCVA at the final follow-up in the rapid control group was 0.30 ± 0.32 logMAR; although this value showed less improvement compared to 0.16 ± 0.15 logMAR in the basic control group ($P = 0.0422$), the value in the rapid control group was significantly greater than the pre-surgery value in this group (1.26 ± 0.74 logMAR) ($P < 0.001$) (Figure 1).

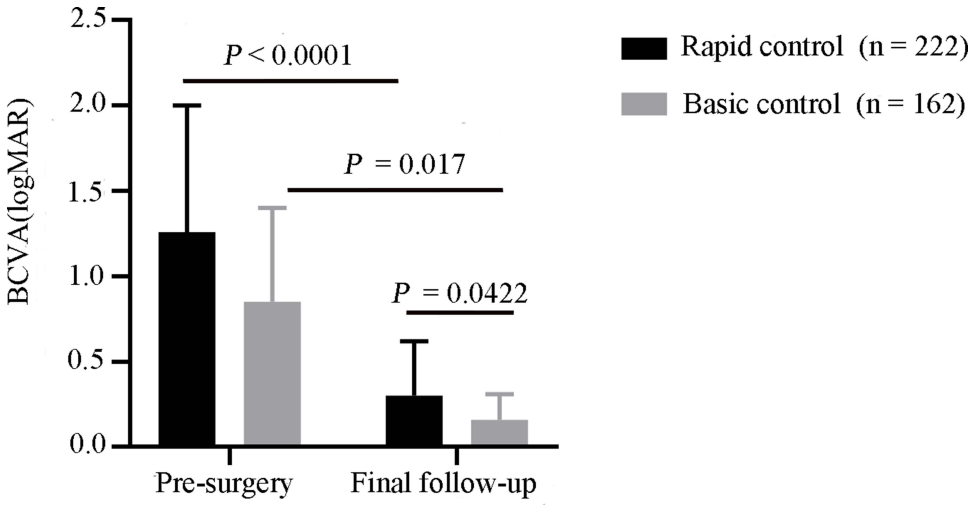

Figure 1 Comparison of BCVA before surgery and at the final follow-up in the two groups.

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Discussion

High HbA1c values and glycemic levels are recognized as important risk factors for vision-threatening complications.[15] Although cataract surgery is a mature surgical technique that performed in type 2 diabetes patients, and uneventful cataract surgery is not considered to be related to DR progression,[16] glycemic control in type 2 diabetes patients with high HbA1c levels and hyperglycemia remains an important step before cataract surgery due to the risks of postoperative infection and severe inflammatory response. Nevertheless, rapid control of chronic hyperglycemia in patients with longstanding poorly glycemic control can be associated with worsening microvascular complications, including DR and other vascular diseases of the whole body.[17] During the period of rapid glycemic control, it needs to pay attention to the patient's overall condition for ensuring patient safety during the perioperative period, especially for patients with long-standing, poorly controlled diabetes.[18] Currently, few studies have reported the effects of rapid preoperative glycemic control on the outcomes of cataract surgery in type 2 diabetes patients.[19] Therefore, the duration of rapid glycemic control before cataract surgery is a topic worth discussing.

In this study, our results revealed an obvious improvement in postoperative BCVA in both the rapid and basic glycemic control groups, which was consistent with previous studies showing that cataract surgery can improve postoperative visual acuity in patients with type 2 diabetes.[20,21] Hyperglycemia is associated with an increased risk for inflammation, infection, and delayed wound healing in the eye.[22] In our study, we found rapid glycemic correction during the perioperative period before surgery did not increase the risk of endophthalmitis, hyphema or incision leakage after surgery owing to the perioperative nursing strategies, and it is considered as an important positive aspect.

Cataract surgery performed in patients with type 2 diabetes is beneficial for facilitating the adequate screening and treatment of DR.[23] Rapid improvement in glycemic control before cataract surgery may lead to the postoperative progression of severe retinopathy.[24] The mechanism underlying for the worsening of retinopathy is not well established, and changes of intravascular osmotic pressure and possible synergistic effect of vascular endothelial growth factor on retinal vessels were the proposed mechanisms.[25] In our study, patients with moderate to severe NPDR before surgery accounted for 40.5% of the patients in rapid control group, which was obviously higher than the 21.0% of the patients in the basic control group, and 9.5% and 8.0% of patients with moderate to severe NPDR before surgery underwent retinal photocoagulation according to the degree of DR diagnosed at the early time after surgery in the two groups, respectively. As a result, we found that a higher percentage of severe complications of DR after cataract surgery following rapid glycemic correction was frequently observed during the follow-up but no prior history of DR treatment, indicating that rapid glycemic fluctuation leads to progression for DR, which was similar to the reports by previous studies[3] and supported by a recognized view that rapid correction of chronic hyperglycemia has a negative influence on macrovascular complications.[26]

DME still is the main cause of visual impairment in type 2 diabetes patients affected by DR.[27] Rachmilevich et al have investigated that 9.1% of type 2 diabetes patients did develop macular edema after cataract surgery, and high HbA1c level was reported to be an independent risk factor of DME.[28] Additionally, previous studies have reported that the percentage of maculopathy progression after cataract surgery following rapid glycemic control reached 33% for 12 months postoperatively, especially in patients with moderate to severe NPDR, and rapid glycemic control may increase the risk of postoperative progression of retinopathy and maculopathy.[3] However, the risk factors of DME for cataract patients following rapid glycemic correction are still not be defined. In the present study, we investigated whether rapid glycemic correction and severity of DR were responsible for severe complications of DR, including DME post-cataract surgery, and we found 9.0% of patients in rapid control group had postoperative DME, and was higher than 3.7% in basic control group. Further analysis revealed that postoperative complications of DR in patients with high HbA1c levels were associated with rapid glycemic control and severity of DR. However, we found that only 0.9% of patients with intervention of retinopathy developed severe complications of DR during the follow-up, indicating that timely intervention for DR may prevent the complications in patients with moderate to severe NPDR after cataract surgery following rapid glycemic control. Therefore, postoperative follow up should be strengthened for diabetes patients undergoing cataract surgery following rapid glycemic control.

There were several limitations in our study. First, this study was a retrospective study with small simple size, which limited the adjustment of some potential confounding factors. Second, the diagnosis and grading of DR was based on

medical records from ophthalmic examinations by fundus physicians. However, diabetic retinopathy was graded by a clinical assessment based on the International Clinical Diabetic Retinopathy Severity Scales.[29]

Conclusion

Our study indicated that rapid glycemic correction did not increase the risk of endophthalmitis, hyphema or incision leakage after surgery, it appeared to be possible to perform cataract surgery for type 2 diabetes patients with high HbA1c levels following rapid glycemic correction during perioperative period from the safety and effectiveness. But it should be noted that rapid glycemic fluctuation may have a risk of complications of DR in patients with type 2 diabetes after cataract surgery. Postoperative follow-up should be strengthened. Our study provides a guidance of the optimal preoperative glycemic control strategy for type 2 diabetes patients undergoing cataract surgery.

Data Sharing Statement

The datasets used and/or analyzed in the retrospective study are available from the corresponding author upon reasonable request.

Ethics Statement

The study was approved by the ethics committee of Qingdao Eye Hospital (2024-15) and was conducted in accordance with the principles of the Declaration of Helsinki. Considering the retrospective nature of the study, the ethics committee of Qingdao Eye Hospital did not require formal consent. All medical data of patients were anonymized and handled in accordance with institutional and national guidelines to ensure confidentiality.

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Disclosure

The authors have no conflicts of interest to declare for this work.

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