



Anesthesia techniques and the risk of complications as reflected in the European Registry of Quality Outcomes for Cataract and Refractive Surgery

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Purpose: To determine the trends in anesthesia techniques for cataract surgery over the past decade and their relationship to surgical complications.

Setting: Clinics affiliated with the European Registry of Quality Outcomes for Cataract and Refractive Surgery (EUREQUO).

Design: Retrospective cross-sectional register-based study.

Methods: Variables include patient demographics, visual acuity, ocular comorbidities, surgery characteristics, intraoperative complications, and postoperative complications for the study period from January 2008, to December 2018. The anesthesia methods registered in the EUREQUO and included in the study are topical, combined topical and intracameral, sub-Tenon, regional, and general anesthesia. Multivariate logistic regression models for each complication were constructed to estimate the adjusted odds ratio (OR) and 95% CIs.

Results: Complete data were available of 1 354 036 cataract surgeries. Topical anesthesia increased significantly over

time (from 30% to 76%, $P < .001$). Sub-Tenon and regional anesthesia decreased (from 27% and 38% to 16% and 6%, respectively, $P < .001$), and general and combined topical and intracameral anesthesia remained stable (around 2%). Sub-Tenon (OR, 0.80; 95% CI, 0.71-0.91, $P < .001$), regional (0.74; 95% CI, 0.71-0.78, $P < .001$), general (0.53; 95% CI, 0.50-0.56, $P < .001$), and intracameral anesthesia (0.76; 95% CI, 0.64-0.90, $P = .001$) carried a significantly decreased risk of posterior capsule rupture (PCR), with and without dropped nucleus, compared with topical anesthesia. The risk of endophthalmitis was significantly lower with regional anesthesia compared with topical anesthesia (OR, 0.60; 95% CI, 0.44-0.82, $P = .001$).

Conclusions: The use of topical anesthesia for cataract surgery increased over time. Topical anesthesia is associated with an increased risk of PCR with and without dropped nucleus, and endophthalmitis.

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Over the past few decades, cataract surgery has become minimally invasive, thanks to modern techniques such as phacoemulsification, femto-second laser-assisted surgery, foldable intraocular lenses, and clear corneal incisions. These improvements went hand in hand with developments in anesthesia techniques. In the 1980s, regional anesthesia (retrobulbar or

peribulbar) was the most applied method.¹ Regional anesthesia provides adequate akinesia and excellent analgesia but carries a potential risk of sight-threatening and life-threatening complications, such as retrobulbar hemorrhage, globe perforation, and brain stem anesthesia.² With a trend toward safer anesthesia, needle-less techniques have been developed. Sub-Tenon anesthesia

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uses a blunt-ended cannula. However, tissue dissection is necessary, and if an anesthesiologist performs the sub-Tenon anesthesia, this is an ocular surface dissection in a clean but nonsterile environment. Consequently, anesthesia-related complications still occur, such as orbital hemorrhage, infection, and muscle trauma.³

At the turn of the century, topical anesthesia gained popularity as a safe, noninvasive method.¹ Previous studies have reported an acceptable level of pain suppression and a fast visual recovery postoperatively with topical anesthesia. Nonetheless, it only blocks the trigeminal nerve endings in the cornea and conjunctiva and does not anesthetize extraocular muscles or intraocular structures. Consequently, patients can move their eyes during surgery, and manipulating the iris can result in discomfort. Controversy exists whether this lack of akinesia could increase the risk of surgical complications.

Few studies have investigated the risk of surgical complications between different anesthesia techniques. Lee et al. and Sivanesan et al. conducted a literature review comparing prospective randomized trials on the incidence of posterior capsule rupture (PCR) in kinetic and akinetic anesthesia methods.^{4,5} They found no significant difference between the 2 groups. However, studies included in these analyses were small, and surgical complications were not the primary study outcome. Moreover, Garcia-Arumi et al. suggested that topical anesthesia might be associated with an increased risk of endophthalmitis compared with regional anesthesia.⁶ They reported a relatively high endophthalmitis rate of 0.87% with topical anesthesia and 0.18% with retrobulbar anesthesia, but the sample size was insufficient to determine such differences with a high level of certainty.

This study aims to determine the trends in anesthesia methods for cataract surgery over the past decade and their relationship with surgical and postoperative complications. The analyses are based on the European Registry of Quality Outcomes for Cataract and Refractive Surgery (EUREQUO), a large, multinational registry for cataract and refractive surgery.

METHODS

Data Source

Data for this study were derived from the EUREQUO. The EUREQUO is a large, multinational registry under the auspices of the ESCRS and consists of cataract and refractive surgeries performed in different clinics, mainly in Europe. From 2008 to 2018, a total of 2 853 376 surgeries were reported to the EUREQUO. Clinics affiliated with the EUREQUO commit to reporting their consecutive cases of cataract or refractive surgery. In this study, only data from cataract surgeries were used. The coding guidelines describe how variables are defined and how they should be reported. The details of the EUREQUO and data entry are described elsewhere.^{7,8} All data reported are anonymous. The study conformed to the tenets of the Declaration of Helsinki.

Study Parameters and Study Sample

All reported cataract surgeries over an 11-year period, between January 1, 2008, and December 31, 2018, were included in this study if they had complete data according to the study parameters. The excluded cases did not substantially differ from the included

cases regarding reported complications. The EUREQUO database includes patient demographics, visual acuity, ocular comorbidities, surgery characteristics, intraoperative complications, and postoperative complications. Parameters included in this study were sex, age, country of origin, preoperative corrected distance visual acuity, target refraction, coexisting eye diseases, complicating comorbidities, anesthesia technique, year of surgery, PCR, dropped nucleus, and endophthalmitis. The anesthesia methods registered in the EUREQUO and included in the study are topical, topical plus intracameral, general, sub-Tenon, and regional anesthesia. PCR is defined as an intraoperative tear in the posterior capsule with or without zonular dialysis and vitreous loss. Dropped nucleus is defined as a loss of lens nucleus fragments or the whole lens into the vitreous cavity. Endophthalmitis is defined as clinical signs of an intraocular infection.

Statistical Analyses

Statistical analyses were performed using SPSS software for Windows (v. 25, SPSS, Inc.). Categorical variables were summarized by frequency and percentage. A linear regression model was constructed to analyze the trend in anesthesia over the years with the percentage of each anesthesia method as the dependent variable and the year of surgery as the independent variable. Separate multivariate logistic regression models were constructed to analyze the relationship between anesthesia techniques and PCR, with and without dropped nucleus, and endophthalmitis. Possible confounders for each complication were based on previous studies and were included in the multivariate model.⁹⁻¹¹ The multivariate logistic regression model with PCR as dependent variable included anesthesia, age, sex, preoperative corrected distance visual acuity in logMAR, glaucoma, diabetic retinopathy, other coexisting eye disease, target refraction, small pupil, white cataract, corneal opacities, pseudoexfoliation, other complicating comorbidities, year of surgery, and country as independent variables. The multivariate logistic regression model with endophthalmitis as dependent variable included anesthesia, age, sex, PCR, year of surgery, and country. A *P* value of less than 0.05 was considered statistically significant.

RESULTS

Anesthesia Trends

There were complete data available on 1 354 036 cataract surgeries. Most of these surgeries (60.7%, *n* = 821 344) were performed with topical anesthesia, 20.5% (*n* = 277 717) with sub-Tenon anesthesia, 14.5% (*n* = 196 725) with regional anesthesia, 2.2% (*n* = 29 138) with combined topical and intracameral anesthesia, and 2.2% (*n* = 29 112) under general anesthesia. **Table 1** presents the demographics stratified by the anesthesia technique. **Figure 1** shows that the number of surgeries performed with topical anesthesia increased significantly over the years (*P* < .001). Although the use of sub-Tenon and regional anesthesia decreased, the use of combined topical and intracameral and general anesthesia remained stable.

PCR and Dropped Nucleus

Table 2 presents the percentage of PCR without dropped nucleus per anesthesia technique and the adjusted odds ratios with 95% CIs from the multivariate logistic regression analysis. This table summarizes that general, sub-Tenon, regional, and intracameral anesthesia methods each have a significantly decreased risk of PCR compared with topical anesthesia. Analysis of PCR with dropped nucleus

Table 1. Demographics of patients included in the study stratified by the anesthesia technique

Parameter	Topical	General	Sub-Tenon	Regional	Topical + intracameral
Female	58.2 (478 370)	59.6 (17 360)	57.5 (159 574)	57.8 (113 666)	59.0 (17 189)
Right eye	50.5 (414 551)	50.8 (14 800)	50.5 (140 126)	50.5 (99 362)	50.6 (14 753)
Age	73.5 ± 9.1	66.4 ± 12.8	74.1 ± 9.4	73.4 ± 10.0	75.5 ± 9.2
Preop CDVA	0.33 ± 0.25	0.45 ± 0.34	0.37 ± 0.27	0.41 ± 0.32	0.44 ± 0.26
Amblyopia	1.6 (13 539)	2.7 (794)	1.9 (5229)	1.7 (3342)	2.2 (647)
Macular degeneration	8.0 (65 311)	5.5 (1614)	9.1 (25 238)	8.0 (15 834)	10.7 (3127)
Glaucoma	5.0 (40 705)	8.4 (2445)	6.4 (17 896)	5.1 (10 069)	8.0 (2317)
Diabetic retinopathy	2.1 (16 886)	3.3 (952)	3.2 (8788)	2.6 (5080)	3.5 (1015)

Data are % (N) or mean ± SD

yielded similar results (general, sub-Tenon, regional, and intracameral anesthesia have a significantly decreased risk compared with topical anesthesia [$P < .001$]).

Endophthalmitis

Table 3 presents the results of the multivariate regression analysis of the risk of endophthalmitis per anesthesia technique. The risk of endophthalmitis was significantly decreased with regional compared with topical anesthesia. There was no statistical evidence that general, sub-Tenon, and intracameral anesthesia have an increased risk of endophthalmitis compared with topical anesthesia.

DISCUSSION

This study explored trends in anesthesia techniques and their relationship to surgical and postoperative complications in a large, multinational registry for cataract surgery (EUREQUO). Our results demonstrate that the use of topical anesthesia increased significantly in the past decade, whereas the use of sub-Tenon and regional anesthesia decreased. The risk of PCR was lower with general, sub-Tenon, regional, and combined topical and intracameral anesthesia compared with topical anesthesia alone. The risk of endophthalmitis was lower with regional compared with topical anesthesia.

The increasing popularity of topical anesthesia aligns with recent studies from other parts of the world where it was used in 55.1%, 64%, 69%, and 95.5% of cataract surgeries.^{12–15} In a recent worldwide survey, Rossi et al. also showed that topical

anesthesia was used in >90% of routine cases in 81% of responding countries.¹⁶ Likewise, in the United States, there has been an increasing trend for topical anesthesia from 8% in 1995 to 51% in 2000 and 61% in 2003.¹⁷

Several studies investigated the association between PCR and anesthesia techniques. Lee et al. and Sivanesan et al. performed a literature review to evaluate the difference in the incidence of PCR between kinetic and akinetic anesthesia and reported no statistically significant difference.^{4,5} By contrast, a study by the Malaysian Cataract Surgery Registry analyzed the risk of PCR between different anesthesia methods and reported that topical and combined topical and intracameral anesthesia had a decreased risk of PCR.¹⁸ However, these results were based on univariate analysis. Selection bias may have played a role because patients undergoing cataract surgery with topical anesthesia are less likely to have comorbidities and patients without comorbidities are less likely to have a PCR. In our study, we conducted a multivariate analysis and included possible confounders, such as comorbidities and year of surgery. We demonstrated a decreased risk of complications with sub-Tenon, regional, general, and topical combined with intracameral anesthesia compared with topical anesthesia alone. Possible explanations for this decreased risk could be less ocular movement and better pain control.

Table 2. Relation between PCR without dropped nucleus and anesthesia techniques

Anesthesia technique ^a	N (%)	Adjusted OR (95% CI)	P value
Topical	7867 (0.96)	—	—
General	315 (1.08)	0.80 (0.71, 0.91)	<.001
Sub-Tenon	2307 (0.83)	0.74 (0.71, 0.78)	<.001
Regional	1370 (0.70)	0.53 (0.50, 0.56)	<.001
Topical + intracameral	201 (0.69)	0.76 (0.64, 0.90)	.001

OR = odds ratio; PCR = posterior capsule rupture

Number and percentage of PCR for each anesthesia technique and multivariate logistic regression model with adjusted ORs, 95% CIs, and P values

Dependent variable: PCR. Independent variables: anesthesia, age, sex, preoperative CDVA in logMAR, glaucoma, diabetic retinopathy, other coexisting eye diseases, target refraction, small pupil, white cataract, corneal opacities, pseudoexfoliation, other complicating comorbidities, year of surgery, and country.

^aReference category: topical anesthesia

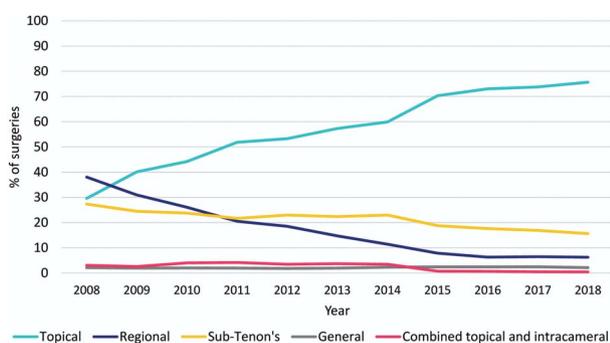


Figure 1. Trends in anesthesia techniques in the European Registry of Quality Outcomes for Cataract and Refractive Surgery between 2008 and 2018.

Table 3. Relation between endophthalmitis and anesthesia techniques

Anesthesia technique ^a	N (%)	Adjusted OR (95% CI)	P value
Topical	238 (0.029)	—	—
General	5 (0.017)	0.48 (0.18, 1.27)	.141
Sub-Tenon	70 (0.025)	0.81 (0.62, 1.06)	.126
Regional	55 (0.028)	0.60 (0.44, 0.82)	.001
Topical + intracameral	1 (0.003)	0.34 (0.02, 6.84)	.478

OR = odds ratio; PCR = posterior capsule rupture

Number and percentage of endophthalmitis for each anesthesia method and multivariate logistic regression model with adjusted ORs, 95% CIs, and P values

Dependent variable: endophthalmitis. Independent variables: anesthesia, age, sex, PCR, year of surgery, and country.

^aReference category: topical anesthesia

The results of our study seem to indicate that the risk of endophthalmitis is higher with topical compared with regional anesthesia. This finding is in line with previous studies by Garcia et al. and Ellis et al.^{6,19} They reported a complication rate of 0.87% and 1.8% with topical anesthesia and 0.18% and 0.48% with retrobulbar anesthesia, respectively. A possible explanation for this higher risk with topical anesthesia could be that due to eye movements, the corneal incisions could come into contact with contaminated areas, such as the eyelids, eyelashes, and conjunctival fornix. However, intracameral and postoperative antibiotic use is outside the scope of the registry, and it is unknown if this is comparable between the anesthesia methods. Another explanation might be that this higher risk with topical anesthesia is an indirect effect because topical anesthesia has a higher risk of PCR, and PCR is associated with a higher risk of endophthalmitis.⁹ We included PCR in the multivariate analysis, and topical anesthesia remained associated with a higher risk of endophthalmitis compared with regional anesthesia. Nonetheless, endophthalmitis is, fortunately, a rare complication, and even with a large data set as the EUREQUO, there are not enough cases to determine the relationship between endophthalmitis and anesthesia methods with a high level of certainty.

A limitation of the study is that the analyses are bound to the parameters registered in the EUREQUO and other factors to consider when choosing anesthesia, for example, patient comfort or anesthesia-related complications, such as retrobulbar hemorrhage and globe perforation, cannot be investigated with the data of the registry because the number of parameters has to be kept low to reduce the clinical burden of reporting data. Another limitation is the risk of underreporting complications because the surgeries are self-reported by surgeons and clinics. In a previous validation study, Lundström et al. showed a sensitivity (registered complications divided by actual complications) of 65.5% and a specificity of 99.8% in the Swedish National Cataract register.²⁰ Nonetheless, clinics are committed to reporting consecutive cases, and the PCR and endophthalmitis rates in the study cohort (0.9% and 0.03%) are in

line with those of recent literature (between 0.6% and 3.2% and 0.04%, respectively).^{18,21,22} Moreover, the data of each surgeon or clinic are only visible to themselves. The main strength of this study is the large number of cases from various countries for more than a decade, making the findings more robust and generalizable.

In conclusion, we found that the risk of PCR with and without dropped nucleus was lower with sub-Tenon, general, regional, and combined topical and intracameral anesthesia compared with topical anesthesia alone. The results indicate that the risk of endophthalmitis was lower with regional compared with topical anesthesia.

WHAT WAS KNOWN

- Topical anesthesia is the most used anesthetic in modern cataract surgery.

WHAT THIS PAPER ADDS

- There is a growing trend for topical anesthesia in cataract surgery in Europe.
- Topical anesthesia alone is associated with a higher risk of posterior capsule rupture, with and without dropped nucleus, and endophthalmitis.

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