Comparison of the efficacy of povidone–iodine 1.0%, 5.0%, and 10.0% irrigation combined with topical levofloxacin 0.3% as preoperative prophylaxis in cataract surgery

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PURPOSE: To compare the efficacy of povidone–iodine 1.0%, 5.0%, and 10.0% in combination with topical levofloxacin 0.3% in reducing the preoperative conjunctival bacterial load before cataract surgery.

SETTING: Department of Ophthalmology, Ludwig-Maximilians-University, Munich, Germany.

DESIGN: Randomized clinical trial.

METHODS: This study enrolled patients scheduled for cataract surgery between July 2010 and January 2011. All patients received topical levofloxacin 0.3% 4 times on the preoperative day and were randomly assigned to these study groups: Group 1 (povidone–iodine 1.0%), Group 2 (povidone–iodine 5.0%), and Group 3 (povidone–iodine 10.0%). In all groups, the conjunctiva was flush irrigated with 10 mL of povidone–iodine of the respective concentration. Conjunctival specimens were obtained at 4 timepoints: baseline (no-surgery eye), before povidone–iodine irrigation, after povidone–iodine irrigation, and at the end of surgery. All specimens were inoculated onto blood and chocolate agars and into thioglycolate broth.

RESULTS: The study was completed by 271 patients. In the control smear (no-surgery eye), no significant difference in positive cultures was found. After 10 mL povidone–iodine irrigation, a considerable reduction in the conjunctival bacterial load occurred in all groups. The difference in positive cultures was statistically significant between Group 1 and Group 3 ($P=.024$) and between Group 2 and Group 3 ($P=.029$). Coagulase-negative *Staphylococcus* was the most commonly isolated bacteria in all groups.

CONCLUSION: Povidone–iodine 10.0% was more effective than povidone–iodine 1.0% and 5.0% in decreasing the conjunctival bacterial load before surgery.

Financial Disclosure: No author has a financial or proprietary interest in any material or method mentioned.

J Cataract Refract Surg 2013; ■:■–■

The incidence of postoperative endophthalmitis after cataract extraction has fallen because of progress in surgical techniques and the use of routine preoperative prophylaxis. Despite these efforts, recent studies[1–3] show a rate of postoperative endophthalmitis after cataract surgery of 0.04% to 0.29%. Because of the high number of cataract surgeries performed throughout the world and the impact of postoperative endophthalmitis on visual function, infectious postoperative endophthalmitis remains an important public health problem. The most commonly identified bacteria in postoperative endophthalmitis are coagulase-negative *Staphylococcus* (CoNS) followed by *Staphylococcus aureus*, and enterococci.[3]

The patient's own conjunctival and lid flora is regarded as the major source of bacteria responsible for postoperative endophthalmitis.[4] Therefore, meticulous preoperative prophylaxis aims at reducing the risk for postoperative endophthalmitis by minimizing the conjunctival bacterial load as much as possible. Principles of preventing postoperative endophthalmitis include the adoption of routine prophylactic measures,

0886-3350/$ - see front matter
http://dx.doi.org/10.1016/j.jcrs.2013.02.039

such as strict hospital policies to prevent nosocomial infections, disinfecting the skin in the periorbital region, and irrigation of the conjunctiva using topical povidone–iodine with the goal of providing a sterile operative field.

The use of topical antibiotics for 1 or 3 days before surgery and preoperative povidone–iodine disinfection of the periorbital skin and the conjunctival sac before intraocular surgery have been shown to be safe and effective in reducing the conjunctival bacterial load.[5–12] However, only povidone–iodine antisepsis has proven to actually reduce the risk for endophthalmitis after cataract surgery.[13]

To our knowledge, the currently used povidone–iodine concentration for ophthalmic use is between 0.01% and 10.0% throughout the world and the most reported preferable concentration seems to be 5.0% according to the published studies.[5,6,11,14–16] However, the optimum concentration of povidone–iodine to provide the best reduction in the bacterial flora of the conjunctiva and eyelids without toxicity is not known.

The purpose of the current study was to compare the effect of flush irrigation of the conjunctival sac with 10 mL povidone–iodine 1.0%, 5.0%, and 10.0% in combination with topical levofloxacin 0.3% in decreasing the conjunctival bacterial load before cataract surgery.

PATIENTS AND METHODS

This prospective clinical quality-control trial was performed according to the World Medical Association (WMA) Declaration of Helsinki under the Policy of "Ethical Principles for Medical Research Involving Human Subjects," adopted by the 18th WMA General Assembly, Helsinki, Finland, June 1964. On this basis, all patients provided informed consent before they were included in this study after approval by the Ethics Commission of the Institutional Review Board, Ludwig-Maximilians-University. Patients presenting for cataract surgery at the Department of Ophthalmology, Ludwig-Maximilians-University, Munich, between July 2010 and January 2011 were eligible to participate in this study.

Inclusion criteria were age over 39 years, no acute infectious or ocular disease, no allergy to iodine or fluoroquinolone antibiotics, and no current use of antibiotics (ophthalmic or otherwise). Patients who did not meet the inclusion criteria, were not able to understand the characteristics and objectives of the study, or with acute conjunctivitis, blepharitis, or dacryocystitis were excluded. General patient information, including age, sex, systemic diseases, and eye symptoms, was recorded.

All patients received topical levofloxacin 0.3% 4 times a day on the day before surgery. Before surgery, the patients were randomly assigned to 1 of the 3 study groups: Group 1 (povidone–iodine 1.0%), Group 2 (povidone–iodine 5.0%), and Group 3 (povidone–iodine 10.0%). In the preoperative area, all patients had standard periorbital disinfection using a povidone–iodine 10.0% scrub on the eyelids and surrounding skin followed by application of gauze soaked with povidone–iodine 10.0% on the closed lids for 5 minutes after topical anesthetic eyedrops had been applied. Then, the patients were transferred into the operating room and the conjunctival sac was irrigated with 10 mL of povidone–iodine solution of the respective concentration. Next, the brow, upper and lower eyelids, eyelashes, and the adjacent forehead, nose, cheeks, and temporal orbital area were again scrubbed with povidone–iodine 10.0% just before surgery. Afterward, sterile draping was applied and the conjunctiva was irrigated with saline solution before the beginning of surgery. By this protocol, an exposure time of povidone–iodine applied into the conjunctival sac of 2 minutes was guaranteed.

Cultures were obtained from the inferior conjunctiva using a Culture Swab EZ (BD-BBLTM Collection and Transport System, Becton, Dickinson and Co.) moistened with sterile thioglycolate broth (Biomérieux SA) while avoiding contact with the patients' eyelashes at the following 4 timepoints:

1. T0C (baseline) from no-surgery eye.
2. T0 from surgery eye before povidone–iodine application (after topical levofloxacin 0.3% had been given 4 times, starting on the preoperative day).
3. T1 after 10 mL povidone–iodine irrigation of the respective concentration but before surgery. (An exposure time of povidone–iodine of 2 minutes was confirmed before the cultures were obtained.)
4. T2 at the end of surgery.

Surgery was performed between T1 and T2. The time between T1 and T2 depended on the duration of surgery.

The swab was immediately streaked on the culture media. First it was streaked across blood agar (Biomérieux SA) for microaerophilic and aerobic bacteria using 1 side of the swab and then onto chocolate agar media (Biomérieux SA), which was cultivated in an anaerobic GENbag (Biomérieux SA) for anaerobic bacteria using the opposite side of the swab. This technique allowed an equal distribution of bacteria on both solid agar medias. Finally, the swab was placed in thioglycolate broth. All the media were incubated at 37°C

Submitted: August 20, 2012.
Final revision submitted: December 14, 2012.
Accepted: February 26, 2013.

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Supported in part by China Scholarship Council, Beijing, China; and Santen GmbH, Germering, and Georg and Hannelore Zimmermann Foundation, Munich, Germany.

Presented in part at the annual meeting of the Association for Research in Vision and Ophthalmology, Fort Lauderdale, Florida, USA, May 2011.

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(Memmert Incubator, Thyssen). Incubation time was 3 days for blood agar media and 5 days for chocolate agar media and thioglycolate broth. The results were recorded daily. On solid culture media, the amounts of colony-forming units (CFU) were assessed. The liquid thioglycolate broth was classified as positive growth when it became cloudy within 5 days of incubation and sterile when it maintained its clear, transparent, and original color after 5 days of cultivation. In addition, if after 5 days of cultivation, the presence of visible small colonies was found, the culture was considered positive and bacteria were isolated. Isolated bacterial organisms were identified (Vitek 2, compact, Biomérieux SA), and gram staining was performed.

The persons culturing the specimens were not masked to the patient groups, while the person examining and questioning the patients after surgery was masked to the concentration of povidone–iodine used to avoid prejudgments while assessing the postoperative patient's symptoms. Clinical data, including examination of the conjunctiva, ocular surface, cornea, and anterior chamber, were collected on the second day after surgery according to a standardized protocol.

Statistical analysis was performed using the Wilcoxon-Mann-Whitney *U* test (SPSS, Inc.) and permutation test with 100 000 resamples was computed using Matlab (R2007b, 1984–2007, The Mathworks, Inc.). A *P* value of 0.05 or less was considered significant.

RESULTS

Patient Characteristics

Two hundred seventy-one patients completed the study; 161 patients (59.4%) were women. The mean age of the patients was 71.5 years. Right eyes were operated in 129 cases (47.6%) and left eyes in 142 cases (52.4%). Surgery was performed under local anesthesia in 217 patients (80.1%). The mean duration of surgery was 16.7 minutes. The number of patients under general anesthesia was higher in the povidone–iodine 10.0% group than in the 1.0% and 5.0% groups ($P=.001$).

Distribution and Quantity of Bacteria in the 3 Groups

Thioglycolate Broth Results Considering positive thioglycolate broth culture results, there were no significant differences in baseline cultures (thioglycolate broth) from no-surgery eyes ($P>.05$ between groups) and after 4-time application of levofloxacin 0.3% drops to surgery eyes ($P>.05$ between groups) (Table 1A). The difference in positive cultures in the control eyes without topical levofloxacin and the study eyes after application of topical levofloxacin was significant (Table 1B).

After flush irrigation with 10 mL povidone–iodine in the surgery eyes, positive cultures at T1 were reduced and significant differences were found between Group 2 and Group 3 and between Group 1 and Group 3 ($P=.029$ and $P=.024$, respectively) (Table 1A).

Blood Agar Results Blood agar and thioglycolate broth cultures were similar (Table 1A and Table 1B). There was no significant difference at T0 between the 3 groups ($P=.624$, $P=.512$, $P=.362$). After 10 mL povidone–iodine irrigation (T1), patients in the povidone–iodine 10.0% group had significantly fewer positive blood agar cultures than those in the 5.0%

Table 1A. Comparison of the positive rate of conjunctival swabs in the three groups (N = 271).

	Povidone–Iodine Group, n (*)					
Culture	1.0% (n = 100)	5.0% (n = 87)	10.0% (n = 84)	*P* Value*	*P* Value†	*P* Value‡
Th0C	69 (69.0)	60 (69.0)	60 (71.4)	.308	.395	.259
Th0	55 (55.0)	55 (63.2)	49 (58.3)	.099	.280	.191
Th1	17 (17.0)	14 (16.1)	7 (8.3)	.342	.024	.029
Th2	10 (10.0)	5 (5.7)	8 (9.5)	.080	.379	.120
B0C	52 (53.6)	47 (54.0)	46 (54.0)	.596	.850	.648
B0	26 (26.0)	19 (21.8)	25 (29.8)	.624	.512	.362
B1	12 (12.0)	9 (10.3)	2 (2.4)	.558	.000	.010
B2	8 (8.0)	4 (4.6)	3 (3.6)	.210	.250	.628
C0C	38 (39.2)	26 (29.9)	31 (31.3)	.486	.302	.140
C0	20 (20.0)	23 (26.4)	21 (25.0)	.260	.250	.052
C1	2 (2.0)	1 (1.1)	1 (1.2)	.584	.118	.078
C2	1 (1.0)	0 (0.0)	3 (3.6)	.154	.296	.046

B0C = blood agar (baseline), no-surgery eye; B0 = blood agar, surgery eye before povidone–iodine application; B1 = blood agar after 10 mL povidone–iodine irrigation but before surgery; B2 = blood agar at end of surgery; C0C = chocolate agar (baseline), no-surgery eye; C0 = chocolate agar, surgery eye before povidone–iodine application; C1 = chocolate agar after 10 mL povidone–iodine irrigation but before surgery; C2 = chocolate agar at end of surgery; P–I = povidone–iodine; Th0C = thioglycolate broth (baseline) from no-surgery eye; Th0 = thioglycolate broth from surgery eye before povidone–iodine application; Th1 = thioglycolate broth after 10 mL povidone–iodine irrigation but before surgery; Th2 = thioglycolate broth at the end of surgery

*Comparison 1.0% and 5.0% povidone–iodine groups

†Comparison 1.0% and 10.0% povidone–iodine groups

‡Comparison 5.0% and 10.0% povidone–iodine groups

Table 1B. *P* values comparing the positive rate of swab cultures in the 3 groups.

Comparison*	P–I 1.0% (n = 100)	P–I 5.0% (n = 87)	P–I 10.0% (n = 84)
Th0C vs Th0	.006	.006	.006
Th0 vs Th1	.000	.000	.000
B0C vs B0	.000	.000	.000
B0 vs B1	.012	.012	.000
C0C vs C0	.000	.000	.000
C0 vs C1	.000	.006	.000

P–I = povidone–iodine
*See Table 1A for definition of culture abbreviations

group and the 1.0% group, respectively ($P=.010$ and $P=.000$, respectively).

After 3 days, amounts of CFU of aerobic and microaerophilic bacteria were assessed on blood agar cultures. Comparing isolated bacteria after 10 mL povidone–iodine irrigation (T1), 67 colonies were isolated from 12 positive eyes in the povidone–iodine 1.0% group and 56 colonies from 9 positive eyes in the povidone–iodine 5.0% group; 2 colonies were isolated after irrigation with 10 mL povidone–iodine 10.0% (Table 2A).

Chocolate Agar Results Chocolate agar cultures showed the distribution of anaerobic bacteria, such as *Propionibacterium acnes* (Table 1A). After levofloxacin 0.3% eyedrops 4 times on the day before surgery (T0), no significant difference was found between the 3 groups ($P=.260$, $P=.250$, and $P=.052$, respectively). After 10 mL povidone–iodine irrigation (T1), 2 eyes in the povidone–iodine 1.0% group showed growth of P *acnes*, 1 eye in the povidone–iodine 5.0% group was positive, and 1 eye in the povidone–iodine 10.0% group was positive ($P=.584$, $P=.118$, and $P=.078$, respectively). At the conclusion of surgery (T2), *P acnes* was found in 3 eyes in the povidone–iodine 10.0% group and 1 eye in the povidone–iodine 1.0% group; no positive cultures were found in the povidone–iodine 5.0% group ($P=.296$ and $P=.046$, respectively). When CFU of anaerobic bacteria were assessed on chocolate agar cultures after 5 days, there was no significant difference between the 3 groups at T0 ($P=.732$) or T1 ($P=.564$) (Table 2B).

Identified Bacteria from Thioglycolate Broth, Blood Agar, and Chocolate Agar Cultures

Three hundred seventeen (74.9%) of 423 identified bacteria were CoNS, which was the most common bacterium in thioglycolate broth cultures. *Propionibacterium acnes* (56/423 [13.2%]), *S aureus* (15/423 [3.5%]), α-hemolytic *Streptococcus* (14/423 [3.3%]), and enterococci (11/423 [2.6%]) were also identified in thioglycolate broth cultures taken from the surgery eyes (Table 3 and Figure 1, *A*). *Staphylococcus epidermis*, the most common bacteria in this study, was identified in 267 (84.2%) of 317 isolated CoNS in thioglycolate broth cultures (Figure 1, *B*).

Also on blood agar cultures, CoNS was the most common bacteria, identified in 200 (62.9%) of 318 isolated bacteria. This was followed by *Corynebacterium* (103/318 [32.4%]) (Figure 1, *C*).

Follow-up Study

One hundred ninety-eight patients participated in the follow-up study assessing possible side effects of povidone–iodine irrigation, such as damage to the ocular surface, cornea, and conjunctiva.

Surgery eyes in the povidone–iodine 10.0% group, showed more superficial punctate epitheliopathy than surgery eyes in the 1.0% and 5.0% groups ($P=.001$). However, there was no statistically significant difference in patients' symptoms due to alterations of the conjunctiva ($P=.201$) and cornea ($P=.073$) between the 3 groups.

Cells and flare in the anterior chamber of patients were also recorded. No significant differences were detected between the 3 groups ($P=.213$) (Figure 1, *D*).

Table 2A. Colony-forming units of aerobic and microaerophilic bacteria on blood agar culture in the 3 groups (N = 271).

	B0C			B0			B1			B2		
CFU (n)	P–I 1.0% (n = 97)	P–I 5.0% (n = 87)	P–I 10.0% (n = 83)	P–I 1.0% (n = 100)	P–I 5.0% (n = 87)	P–I 10.0% (n = 84)	P–I 1.0% (n = 100)	P–I 5.0% (n = 87)	P–I 10.0% (n = 84)	P–I 1.0% (n = 100)	P–I 5.0% (n = 87)	P–I 10.0% (n = 84)
0	45	40	38	74	68	59	88	78	82	92	83	81
1–5	27	23	22	22	13	19	10	7	2	7	4	3
6–10	12	6	6	1	4	1	1	1	0	0	0	0
11–50	9	11	11	2	2	4	1	1	0	1	0	0
>50	4	7	6	1	0	1	0	0	0	0	0	0
P value		.475			.718			.424			.396	

B0C = blood agar (baseline), no-surgery eye; B0 = blood agar, surgery eye before povidone–iodine application; B1 = blood agar after 10 mL povidone–iodine irrigation but before surgery; B2 = blood agar at end of surgery; CFU = colony-forming units; P–I = povidone–iodine

Table 2B. Colony-forming units of anaerobic bacteria on chocolate agar culture in the 3 groups (N = 271).

	C0C			C0			C1			C2		
CFU (n)	P–I 1.0% (n = 97)	P–I 5.0% (n = 87)	P–I 10.0% (n = 83)	P–I 1.0% (n = 100)	P–I 5.0% (n = 87)	P–I 10.0% (n = 84)	P–I 1.0% (n = 100)	P–I 5.0% (n = 87)	P–I 10.0% (n = 84)	P–I 1.0% (n = 100)	P–I 5.0% (n = 87)	P–I 10.0% (n = 84)
0	59	61	52	80	74	63	98	86	83	99	87	81
1–5	26	18	21	14	9	14	2	1	1	1	0	3
6–10	4	4	4	1	3	1	0	0	0	0	0	0
11–50	4	2	3	3	0	6	0	0	0	0	0	0
>50	4	2	3	2	1	0	0	0	0	0	0	0
P value		.421			.732			.564			.121	

C0C = chocolate agar (baseline), no-surgery eye; C0 = chocolate agar, surgery eye before povidone–iodine application; C1 = chocolate agar after 10 mL povidone–iodine irrigation but before surgery; C2 = chocolate agar at end of surgery; CFU = colony forming units; P–I = povidone–iodine.

In addition, none of the 271 patients in the study developed postoperative endophthalmitis or any surgical complication. Furthermore, no intolerable adverse reaction to the irrigation solution or swabbing procedure was seen.

DISCUSSION

Postoperative endophthalmitis is a rare complication of cataract surgery. Therefore, studies measuring the direct effect of different preoperative prophylaxis schemes on the rate of postoperative endophthalmitis would require very large numbers of patients and are difficult to perform. Thus, we used the conjunctival bacterial load as a surrogate marker for the risk for postoperative endophthalmitis; this has been done in several studies of postoperative endophthalmitis. However, this method is a compromise because it is based on the assumption that an increased preoperative conjunctival bacterial load is associated with a higher risk for postoperative endophthalmitis. Because studies measuring the direct effect of different prophylactic measures on postoperative endophthalmitis are unlikely to be performed due to the large number of patients needed, the use of this surrogate marker makes it possible to study the effect of different prophylactic measures in a clinical setting. However, one has to bear in mind that studies like ours give information on the conjunctival bacterial load and not directly on the incidence of postoperative endophthalmitis.

It has been shown that patients with risk factors, such as blepharitis or diabetes mellitus, are more likely to harbor methicillin-resistant organisms, which may be a reason for the reported increased risk for postoperative endophthalmitis in these groups of patients.[17] In this study, we excluded patients with local risk factors, including chronic blepharitis, conjunctivitis, and dacryocystitis, because these conditions should be cured before intraocular surgery is performed.

Patients with diabetes mellitus were found to be at higher risk for postoperative endophthalmitis.[18] In our study, diabetes mellitus or chronic obstructive pulmonary disease had been diagnosed in 13 (34.21%) of 38 patients with positive cultures at T1; the percentage of these patients in the whole study population

Table 3. Isolated bacteria from conjunctival swabs in thioglycolate broth by povidone–iodine concentration (N = 423).

	Number											
	Th0C			Th0			Th1			Th2		
Bacteria	1.0% (n = 97)	5.0% (n = 87)	10.0% (n = 83)	1.0% (n = 100)	5.0% (n = 87)	10.0% (n = 84)	1.0% (n = 100)	5.0% (n = 87)	10.0% (n = 84)	10.0% (n = 100)	5.0% (n = 87)	10.0% (n = 84)
CoNS	58	48	48	39	39	34	15	13	6	9	3	5
S aureus	1	7	2	1	2	0	1	0	0	0	0	1
α-Streptococcus	3	3	3	3	2	0	0	0	0	0	0	0
Enterococci	4	2	3	1	0	0	1	0	0	0	0	0
Corynebacterium	1	1	1	0	0	1	0	0	0	1	0	0
Micrococcus sp	1	0	0	0	1	0	0	0	0	0	0	0
Propionibacterium	4	2	4	15	12	13	0	1	1	0	2	2
Gram (–) rods	0	0	1	0	1	1	0	0	0	0	0	0

α-hemolytic *Streptococcus*; CoNS = coagulase-negative *Staphylococcus*; *S aureus* = *Staphylococcus aureus*; sp = species; Th0C = thioglycolate broth (baseline) from no-surgery eye; Th0 = thioglycolate broth from surgery eye before povidone–iodine application; Th1 = thioglycolate broth after 10 mL povidone–iodine irrigation but before surgery; Th2 = thioglycolate broth at the end of surgery

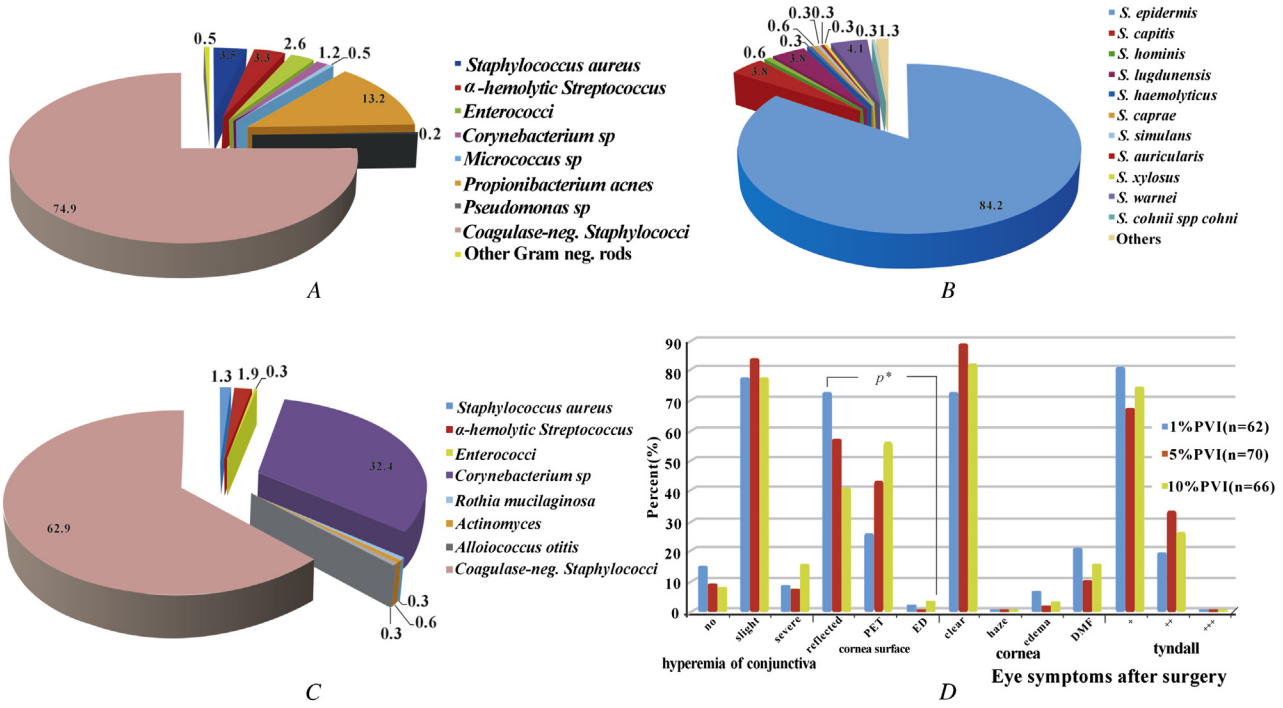

Figure 1. Isolated bacteria from conjunctival swabs and postoperative findings. *A:* Isolated bacteria from conjunctival swabs in thioglycolate broth in percent (n = 423). *B:* Isolated CoNS from conjunctival swabs in thioglycolate broth in percent (n = 317). *C:* Isolated bacteria from conjunctival swabs on blood agar in percent (n = 318). *D:* Comparing the postoperative findings between the 3 groups in percentage (n = 198). Grade of anterior chamber cell (Tyndall): + = mild; ++ = moderate; +++ = severe; n = negative. (*P = .001; DMF = Descemet membrane folds; ED = epithelial defect; neg. = negative; PET = punctate epitheliopathy; PVI = povidone–iodine; sp = species).

was only 24.35% (66/271 patients). Patients older than 75 years, 10 of who were older than 80 years, were responsible for 42.11% (16/38 patients) of positive T1 cultures in our study. This is consistent with a study in which the age of 80 years or older was considered a risk factor for postoperative endophthalmitis.[1,19]

Considering surgical techniques, only patients who had phacoemulsification were included in our study to exclude a possible bias caused by technical differences in cataract surgery. The choice of anesthetic method (local anesthesia versus general anesthesia) did not seem to affect the rate of positive conjunctival swabs at T1 or T2 in this study, although Garcia-Arumi et al.[20] postulated a possible association between topical anesthesia and the rate of postoperative endophthalmitis after cataract surgery.

In 20 patients, we found new isolated bacteria species at T2 that were not present at T1. In 9 (45.0%) of these patients, the duration of surgery (minimum 20 minutes) was considerably longer than average; surgery lasted 30 minutes or longer in 5 patients. This might suggest that a longer duration of surgery is a potential risk factor for postoperative endophthalmitis due to extended manipulation and an additional risk for bacterial contamination.

As in previous studies,[21,22] CoNS was the most commonly identified organism on the conjunctiva in the present study. It represented 78.17% (154/197) of all bacteria isolated from thioglycolate broth cultures at T0C, 67.88% (112/165) at T0, 89.47% (34/38) at T1, and 73.91% (17/23) at T2. Of the 317 CoNS from thioglycolate broth cultures, the most common bacterium (267/317 [84.2%]) was *S epidermis*. In surgery eyes at T0, the bacteria most commonly isolated from conjunctival swabs were CoNS, *P acnes*, *Corynebacterium* species, *S aureus*, and α-hemolytic *Streptococcus*.

Povidone–iodine has a bactericidal effect of within 30 seconds on most bacteria; effectiveness against virus and spores has also been shown.[23,24] To ensure comparability between the groups, care was taken to guarantee a time of action of 2 minutes after flush irrigation of the conjunctival sac. We wanted to exclude bias during postoperative clinical evaluation of patients' symptoms; thus, the person performing this task was masked to the concentration of povidone–iodine used.

From the results of this study, we conclude that flush irrigation of the conjunctival sac with 10 mL of povidone–iodine 10.0% is better than with the 5.0% and 1.0% concentration with regard to the preoperative reduction of the conjunctival bacterial load. After flush irrigation with 10 mL povidone–iodine of the surgery eyes (T1), the difference in positive conjunctival cultures was significant between povidone–iodine 1.0% or 5.0% and povidone–iodine 10.0%.

Previous studies[25,26] suggest that bacteria most commonly gain access into the eye at the beginning and toward the end of cataract surgery. At the end of surgery (T2), there was no significant difference in the rate of positive cultures in the 3 groups ($P > .05$). This finding might be explained by the copious amount of saline irrigation during surgery. This intraoperative irrigation might have diluted bacteria that remained on the ocular surface after povidone–iodine irrigation and therefore influenced the microbiological results. On the other hand, in some cases we also found bacteria at T2 that had not been present at T1. Even though sterile draping and foil were used in all cases, these bacteria may derive from parts of the lashes or eyelids that might not have been completely covered by the draping in some cases and gained access to the conjunctival surface during surgery.

Povidone–iodine has been shown to be cytotoxic in animal studies. After povidone–iodine injection into the anterior chamber, significant corneal edema was observed at concentrations of 2.0% and 1.5%.[10] As little as 1 drop of povidone–iodine 5.0% or 10.0% in the anterior chamber caused severe toxicity in 1 study.[27] Thus, care has to be taken not to introduce any povidone–iodine into the eye during surgery. A healthy ocular surface acts as a barrier to prevent the penetration of povidone–iodine into the eye.[28] The preoperative use of povidone–iodine has been shown to be safe in this respect.[29] Even after irrigation with povidone–iodine 5.0% and 10.0%, no intolerable eye irritation was reported.[11] Irritation of the ocular surface may be explained by the pH of povidone–iodine, which comes closer to the pH of the conjunctiva with higher dilution.[16]

In our study, we found a similar effect. In the follow-up part of our study, we did not notice significant differences in patients' symptoms due to irritation of the conjunctiva, corneal damage, or anterior chamber reaction between the povidone–iodine 1.0%, 5.0%, and 10.0% groups ($P > .05$). No signs of toxicity were found in the anterior chamber because irrigation was performed on an intact ocular surface before surgery. Transient superficial punctuate epitheliopathy was seen in more patients in the povidone–iodine 10.0% group than in the povidone–iodine 1.0% group ($P < .05$), which we assume was caused by the flush irrigation of the conjunctiva using higher concentrated povidone–iodine and the following time for action of povidone–iodine on the ocular surface. However, the presence of this corneal alteration was not noted by the patients; on the questionnaire of postoperative symptoms, there were no significant differences in patient-reported postoperative ocular discomfort between the groups. The increased presence of superficial punctuate epitheliopathy in the povidone–iodine 10.0% group warrants further studies of the possible ocular side effects of higher concentrated povidone–iodine. These studies could give evidence on whether the benefits of the higher concentration of povidone–iodine overcome possible associated risks if studied in a greater number of patients. According to our results, we might conclude that the effectiveness and risks may vary depending on the concentration of povidone–iodine used and possibly on the duration of exposure.

In conclusion, topical povidone–iodine is affordable, has minimal side effects in the typically used concentrations, reduces the conjunctival bacterial load to a great extent, and has been routinely used in preoperative prophylaxis for many years.[11] In addition, some topical antibiotics, such as levofloxacin, have shown additional benefits in terms of reducing the preoperative conjunctival bacterial load.[9]

In the present study, topical levofloxacin 0.3% given 4 times on the preoperative day reduced the conjunctival bacterial load. However, the greatest effect was achieved by povidone–iodine irrigation of the conjunctival sac. Povidone–iodine was effective and well tolerated by patients at all tested concentrations (1.0%, 5.0%, and 10.0%). Povidone–iodine 10.0% resulted in the greatest reduction in the conjunctival bacterial load but was associated with higher rates of superficial punctuate epitheliopathy. Therefore, we recommend strictly adhering to a standardized preoperative prophylaxis protocol that includes flush irrigation of the conjunctival sac with povidone–iodine before cataract surgery.

WHAT WAS KNOWN

- Povidone–iodine has been shown to reduce the preoperative conjunctival bacterial load, which is a well-accepted surrogate parameter for the risk for postoperative endophthalmitis.
- In clinical practice, povidone–iodine is used in different ways and different concentrations as preoperative prophylaxis because the optimum concentration with regard to the elimination of the conjunctival bacterial flora and potential toxicity to the ocular surface have not been established.

WHAT THIS PAPER ADDS

- Povidone–iodine irrigation of the conjunctival sac was effective and well tolerated using 1%, 5%, or 10% solutions.
- The best reduction in the preoperative bacterial load was achieved by flush irrigation of the conjunctival sac with 10 mL of povidone–iodine 10.0% when compared with povidone–iodine 1.0% and 5.0%.

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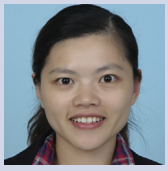

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