Simultaneous Bilateral Pediatric and Juvenile Cataract Surgery Under General Anesthesia: Outcomes and Safety

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• PURPOSE: To evaluate the surgical approach, outcome, and safety of bilateral simultaneous cataract surgery (BS-Cat) compared with unilateral cataract surgery (US-Cat) and bilateral 2-timed cataract surgery (BT-Cat) in children.

• DESIGN: Retrospective, interventional case series.

• METHODS: SETTING: Department of Ophthalmology, Medical University, Vienna, Austria. PARTICIPANTS: Children aged 0-18 years who received cataract extraction owing to a unilateral or bilateral cataract between January 2003 and December 2018 were included. MAIN OUTCOMES AND MEASURES: Information regarding the type and duration of surgery and total anesthesia time were recorded. Additionally, intraoperative and postoperative complications including retreatments were evaluated.

• RESULTS: A total of 220 eyes of 147 patients were included in this analysis (US-Cat: n = 74 patients; BS-Cat: n = 63 patients; BT-Cat: n = 10 patients). The mean age at surgery was 15.94 ± 27.10 months in the US-Cat group, 33.47 ± 58.20 months in the BS-Cat group, and 41.91 ± 55.09 months in the BT-Cat group. The main surgical approach was lensectomy combined with anterior vitrectomy ± IOL implantation (US-Cat: 98.65%; BS-Cat: 95.24%; BT-Cat: 100%; $P = .08$). Initial intraocular lens implantation was not commonly performed in all groups (US-Cat: 27.03%; BS-Cat: 23.02%; BT-Cat: 50.00%). The mean anesthesia time was shortest in the US-Cat (91.62 ± 26.12 min), followed by the BS-Cat (123.81 ± 30.11 min) and BT-Cat groups (186.00 ± 42.34 min; $P < .001$), contrary to the duration of surgery (US-Cat: 37.56 ± 15.69 min; BS-Cat: 32.33 ± 17.31 min; BT-Cat: 37.50 ± 18.67; $P = .087$). An accidental oxygen decrease below 93% was rare in all groups (US-Cat: 6.76%; BS-Cat: 17.46%; BT-Cat: 10.00%). Intraoperative surgical complications occurred rarely ($P = .95$) and involved mainly the iris. The number of postoperative complications ($P = .17$) and interventions ($P = .10$) was similar in all groups. Visual axis obscuration (US-Cat: 28.38%; BS-Cat: 23.81%; BT-Cat: 20.00%; $P = .67$) and glaucoma (US-Cat: 6.76%; BS-Cat: 15.87%; BT-Cat: 15.00%; $P = .20$) showed no difference between the groups. However, nystagmus was more pronounced in the BS-Cat group (US-Cat: 12.16%; BS-Cat: 49.21%; BT-Cat: 20.00%; $P < .001$), whereas strabismus was more pronounced in the US-Cat group (US-Cat: 68.92%; BS-Cat: 33.33%; BT-Cat: 40.00%; $P < .001$).

• CONCLUSION: Simultaneous removal of bilateral cataract in children showed no statistically significant differences regarding intraoperative and postoperative complications when compared to unilateral and 2-timed bilateral cataract surgery. Anesthesia time was longer in simultaneous bilateral than in unilateral cataract surgery, but only by the surgery time of the second eye. However, prolonged anesthesia time was not accompanied by a decrease of oxygen saturation. (Am J Ophthalmol 2020;214:63–71. © 2020 Elsevier Inc. All rights reserved.)

THE SUCCESSFUL MANAGEMENT OF PEDIATRIC CATARACT depends on early detection of the cataract and timely surgical treatment,[1] as the critical period for visual development is from age 2 to 6 months.[2] However, the severity of the media opacity and subsequent grade of amblyopia should guide the decision for surgery.[3] Surgical intervention for unilateral cataract is recommended within the first 6 weeks of life,[4,5] whereas no standardized guidelines exist on the timing and type of surgical intervention in bilateral cataract. Several studies have shown that if treatment is delayed the risk of developing resistance to amblyopia treatment increases and potential visual functions are reduced.[6,7] On the other side, recent studies showed that treatment at an early stage runs the risk of a higher rate of postoperative complications such as secondary membrane formation and the development of aphakic glaucoma.[8,9] Additionally, the safety and surgical feasibility of simultaneous surgery for bilateral cataract cases is discussed. These various aspects of the optimal treatment for bilateral congenital cataract challenge pediatric ophthalmologists in their decision-making.

Over the past 15 years, cataract surgery has been performed in our department in both eyes simultaneously under general anesthesia (even in very young children in

Accepted for publication Jan 3, 2020.

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0002-9394/$36.00
https://doi.org/10.1016/j.ajo.2020.01.001

the first months of life), following strict procedures (Figure 1). This approach was adopted to reduce the time under general anesthesia, which is increased by a second operation. We only refrain from bilateral simultaneous surgery based on individual decisions.

Hence, the aim of the study was to evaluate the surgical approach, outcomes, and safety of simultaneous bilateral pediatric cataract surgery compared with unilateral surgery.

METHODS

THIS RETROSPECTIVE, INTERVENTIONAL CASE SERIES WAS performed at the Department of Ophthalmology, Medical University of Vienna, Vienna, Austria. Approval of the local ethics committee (EK: 1116/2019) was obtained and the study adhered to the tenets of the Declaration of Helsinki.

Medical files of patients aged 0-18 years submitted to cataract extraction owing to a unilateral or bilateral cataract between January 2003 and December 2018 were included in the study. Those with a history of congenital (including metabolic and mitochondrial disorders) or juvenile cataract, as well as cataract associated with the syndromes persistent hyperplastic primary vitreous or congenital cataracts facial dysmorphism neuropathy, were included. However, a history of cataract without cataract surgery, secondary cataract (inflammatory, uveitic), congenital cataract associated with Rieger syndrome, Rieger-Axenfeld syndrome, Peters anomaly, a history of ectopia lentis associated with Marfan syndrome, homocystinuria or Ehlers-Danlos syndrome, a history of penetrating or perforating eye trauma or previous surgery owing to glaucoma, and retinal detachment were reasons for exclusion.

Induction of general anesthesia	
Surgery: first eye	Surgery: second eye
1. Preparation of the surgical and phaco kit	1. Preparation of the surgical and phaco kit
2. Topical iodine and disinfection of surgical area with iodine	2. Topical iodine and disinfection of surgical area with iodine
3. Dressing with sterile clothes and gloves	3. Dressing with sterile clothes and gloves
4. Covering of the surgical area	4. Covering of the surgical area
5. Cataract surgery	5. Cataract surgery
6. Suture of wounds with 10-0 nylon	6. Suture of wounds with 10-0 nylon
7. Topical iodine, removal of covers	7. Topical iodine, removal of covers
8. Removal of surgical and phaco kit, and sterile clothes as well as gloves	8. Removal of surgical and phaco kit, and sterile clothes as well as gloves
Removal of tube	

FIGURE 1. Strict procedure guidelines for simultaneous cataract surgery at the Department of Ophthalmology of the Medical University of Vienna.

Before surgery, orthoptic and ophthalmologic examinations including ultrasound B-scans (Ocuscan; Alcon Laboratories, Fort Worth, Texas, USA) were performed to evaluate the posterior segment if the fundus view was obscured. During general anesthesia, an extensive ophthalmic examination was performed including direct and indirect ophthalmoscopy of the fundus, measurement of intraocular pressure, keratometry and axial eye length. The cataract surgery was performed under general anesthesia in all cases. Initial sedation was reached by halogenated inhalational agents. Afterwards a peripheral intravenous line was established to maintain anesthesia by continuous propofol infusion (10 mg/kg/h). Cataract surgery was performed by 3 experienced surgeons (M.A., A.K., and E.S.). The surgical approach was adapted to the child's age and the state of the lens opacification. In younger children with soft lenses aspiration of the lens material with a bimanual irrigation-aspiration system was performed, whereas a phaco tip was used in older children. A posterior capsulotomy was commonly performed using either a bent needle or vitrector, except in children older than 2 years. Usually, younger children (below 12 months of age) remained aphakic, whereas a primary intraocular lens (IOL) was placed in the bag or sulcus in older children.

• OUTCOME MEASURES: The outcome measures were divided into surgery, anesthesia, and safety.

Descriptive data concerning the patients' sex and age (at initial cataract and secondary IOL implantation) and the time until surgery were collected. Information regarding the *surgical procedure*, comprising the type of surgery, lens implantation (primary or secondary), and the location and time point of the lens implantation, was recorded.

Anesthesia outcomes, composed of duration of surgery and anesthesia (measured in minutes, min)—that is, total anesthesia time (intubation to extubation), extubation time (time between the end of surgery and extubation), time in the recovery room, and events of oxygen decrease (below 93% was regarded as severe hypoxia)—were recorded. The main outcome measure was the total anesthesia time.

Safety was defined as the incidence of intraoperative and postoperative complications related to the cataract surgery. The type of intraoperative complications, such as surgical and anesthetic complications (iris bleeding, expulsive bleeding, posterior capsule rupture, IOL problems, iris dislocation), as well as the type and number of postoperative complications such as hypotony, choroidal hemorrhage, glaucoma, visual axis obscuration (VAO), mystagmus, strabismus, retinal detachment or endophthalmitis, as well as the number of surgical retreatments, were analyzed.

• **GROUP CLASSIFICATION:** Three groups were classified for statistical analysis. The first group comprised children with unilateral cataracts receiving cataract surgery (US-Cat), and the other 2 groups consisted of children receiving surgery owing to bilateral cataract. Further classification was based on the time point of the initial cataract surgery. Therefore, the second group comprised children receiving cataract surgery on the same day for both eyes (bilateral simultaneous cataract surgery, BS-Cat), whereas the third group consisted of children with bilateral cataract receiving sequential surgery (bilateral 2-timed cataract surgery, BT-Cat). The time of anesthesia of the first and second surgery of the BT-Cat group was added for the total anesthesia time.

Two hundred and twenty eyes of 147 patients were included in this analysis, of which the US-Cat group comprised 74 eyes of 74 patients, the BS-Cat group comprised 126 eyes of 63 patients, and the BT-Cat group consisted of 20 eyes of 10 patients (Table 1).

• **STATISTICAL ANALYSIS:** Microsoft Excel 2010 (Microsoft Corp, Redmond, Washington, USA) was used for collecting patients' data, which were then converted to SPSS version 20 (SPSS, Inc, Chicago, Illinois, USA). Nominal data are given as numbers or percentages, whereas continuous data are given as mean ± standard deviation (SD).

Nderitu and associates presented mean anesthesia time of 21 ± 10 minutes in uneventful cataract surgery vs 45 ± 23 minutes in complicated cataract surgery.[10] Sample size calculation with pi-face (Lenth, R. V. (2006-9). Java Applets for Power and Sample Size [Computer software], 2006-9. [Retreived 06 November 2019].) for 1-way analysis of variance showed that a pairwise group comparison between the 3 groups adjusting for multiple testing with Tukey HSD will be able to detect a difference of at least 20 minutes with 80% power if the group size in both compared groups is at least 47 patients; for the smallest group, where only 10 patients can be expected the minimal detectable contrast to the other groups is 45 minutes with a power of 80%. For both calculations an SD of 30 minutes was assumed.

Prior to conducting any inferential analyses, the McNemar test was used to check for independence in surgical-type diagnosis between the left and right eyes of patients. Since there was no significant dependence found ($P = .56$), the eyes were treated independently.

Nominal variables were compared using a χ^2 test or a Fisher exact test if the minimum expected frequency could not be reached in 1 cell of the 4-field chart. An analysis of variance was used for analysis of continuous variables. A P value of $P < .05$ was considered statistically significant.

RESULTS

TABLE 1 SHOWS THE DEMOGRAPHIC INFORMATION OF THE total population and each individual group. A total of 152 eyes of the total population were below 1 year of age at the time of cataract surgery (US-Cat: 54 eyes; BS-Cat: 90 eyes; BT-Cat: 8 eyes). The main diagnosis was congenital cataract in all 3 groups (US-Cat: 50.00%; BS-Cat: 66.67%; BT-Cat: 80.00%). The mean follow-up of the total population was 4.83 ± 3.67 years.

• **SURGERY:** The main type of cataract surgery was lensectomy combined with anterior vitrectomy without a lens implantation (US-Cat: 71.62%; BS-Cat: 72.22%; BT-Cat:

TABLE 1. General Information on the Total Study Population and for Each Group

	Total Population	Unilateral Cat	Bilateral Simultaneous Cat	Bilateral Separate Cat	*P* Value
Number of patients	147	74	63	10	
Number of eyes	220	74	126	20	
Sex (male:female)	85:62	39:35	40:23	6:4	.44[a]
Age in months (range)	28.34 ± 50.25 (0.5-203)	15.94 ± 27.10 (0-128)	33.47 ± 58.20 (1-203)	41.91 ± 55.09 (2-183)	.026[b]
Diagnosis, n (%)					
Congenital Cat	87 (59%)	37 (50.00%)	42 (66.67%)	8 (80.00%)	
Juvenile Cat	9 (6%)	1 (1.35%)	7 (11.11%)	1 (10.00%)	
Mitochondropathy	2 (1%)	0	2 (3.17%)	0	
PHPV	42 (28%)	36 (48.65%)	5 (7.94%)	1 (10.00%)	
CCFDN	3 (2%)	0	3 (4.76%)	0	
Duane syndrome	1 (1%)	0	1 (1.59%)	0	
LOWE syndrome	2 (1%)	0	2 (3.17%)	0	
Cohen syndrome	1 (1%)	0	1 (1.59%)	0	
Follow-up (in years)	4.83±3.67	4.47±3.29	5.14±4.09	4.26±1.74	.36[b]

Cat = cataract; CCFDN = congenital cataracts facial dysmorphism neuropathy; PHPV = persistent hyperplastic primary vitreous.
[a]χ^2 test.
[b]ANOVA.

50.00%), followed by lensectomy with an anterior vitrectomy and IOL implantation (US-Cat: 27.03%; BS-Cat: 23.02%; BT-Cat: 50.00%; $P = .08$). The location of an initially implanted IOL was in the bag in all 3 groups (US-Cat: 20.27%; BS-Cat: 23.81%; BT-Cat: 40.00%; $P = .22$). The age of the children at the time of surgery differed significantly between the groups ($P = .026$). Children in the US-Cat group were the youngest at 15.94 ± 27.10 months, followed by the BS-Cat group at 33.47 ± 58.20 months and the BT-Cat group at 41.91 ± 55.09 months.

A secondary IOL implantation was performed in 56 children of the overall population. No significant difference between the age at implantation ($P = .18$) or the time until secondary IOL implantation ($P = .15$) was found. The main location of IOL placement was in the sulcus in all 3 groups, followed by an anterior chamber lens in the US-Cat and BS-Cat group and in the bag in the BT-Cat group ($P = .019$). Table 2 provides detailed information on cataract surgery for each group.

• **ANESTHESIA:** The total time under general anesthesia differed significantly among the 3 groups ($P < .001$). The shortest duration of total anesthesia time was in the US-Cat group (91.62 ± 26.12 min). The longest time (186.00 ± 42.34 min), which was twice as long as for the US-Cat group, was in the BT-Cat group. The total surgery time and extubation time was not significantly different (total surgery time: $P = .087$; extubation time: $P = .293$). The children in the BS-Cat group were in the recovery room statistically significantly longer (104.78 ± 59.15 min) than the children in the other 2 groups (US-Cat: 89.55 ± 45.07 min; BT-Cat: 70.53 ± 33.99 min; $P = .024$).

However, no differences were found for oxygen saturation between the 3 groups. The number of children in whom oxygen decreased below 93% was similar. In general, an oxygen decrease occurred 0.68 ± 2.28 times during surgery ($P = .34$). Figure 2 shows the distribution of the lowest oxygen saturation levels measured for each group. Additionally, no serious complications such as death, asphyxia, malignant hyperthermia, cardiac and respiratory arrest, or seizures were observed during surgery. Table 3 provides detailed information on anesthesia times for each group.

The bilateral cataract surgery group operated on separate days was analyzed in more detail. The second surgery was performed 5.62 ± 6.12 months (1-21 months) after the first surgery. We observed a trend, which did not reach statistical significance, toward shorter surgery times for all the first surgeries. The total time of anesthesia was 87.50 ±

TABLE 2. Information Regarding Initial Cataract Surgery With or Without Lens Implantation as Well as the Secondary Lens Implantation for the Total Study Cohort and Each Group Separately

	Total Population	Unilateral Cat	Bilateral Simultaneous Cat	Bilateral Separate Cat	*P* Value
Primary lens surgery					.08[a]
Lensectomy + aVE	154 (70.00%)	53 (71.62%)	91 (72.22%)	10 (50.00%)	
Lensectomy + aVE + IOL implantation	59 (26.82%)	20 (27.03%)	29 (23.02%)	10 (50.00%)	
Phaco + IOL	7 (3.18%)	1 (1.35%)	6 (4.76%)	0	
Location of primary lens implantation					.22[a]
No implant	154 (70.00%)	53 (71.62%)	91 (72.22%)	10 (50.00%)	
Capsular bag	53 (24.09%)	15 (20.27%)	30 (23.81%)	8 (40.00%)	
Sulcus	13 (5.91%)	6 (8.11%)	5 (3.97%)	2 (10.00%)	
Time to surgery (in days)	186.20 ± 568.30	52.57 ± 148.81	233.19 ± 659.43	384.52 ± 806.87	.024[b]
Secondary lens surgery					.019[a]
Sulcus	43 (76.79%)	20 (71.43%)	22 (84.62%)	1 (50.00%)	
Anterior chamber lens	10 (17.85%)	6 (21.43%)	4 (15.38%)	0	
Capsular bag	2 (3.57%)	1 (3.57%)	0	1 (50.00%)	
Aphakia	1 (1.79%)	1 (3.57%)	0	0	
Age at IOL surgery (in years)	3.0 ± 2.0	2.57 ± 1.38	3.25 ± 2.17	4.85 ± 5.73	.18[b]
Time to lens implantation (in months)	30.06 ± 22.87	26.08 ± 17.41	35.76 ± 27.11	11.59 ± 15.39	.15[b]
Intraoperative complications					.95[a]
IOL problems	3 (1.36%)	1 (1.35%)	2 (1.59%)	0	
Posterior capsule rupture	2 (0.91%)	1 (1.35%)	1 (0.79%)	0	
Iris bleeding	5 (2.27%)	2 (2.70%)	2 (1.59%)	1 (5.00%)	
Expulsive bleeding	0	0	0	0	
Iris dislocation	0	0	0	0	

aVE = anterior vitrectomy; IOL = intraocular lens; Phaco = phacoemulsification.
[a] χ^2 test.
[b] ANOVA.

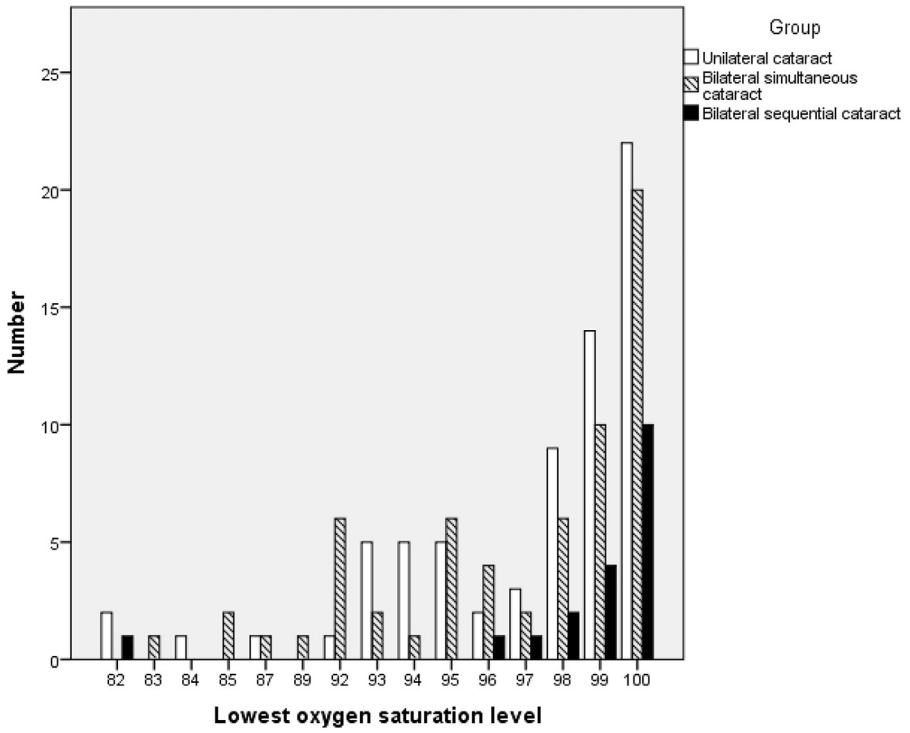

FIGURE 2. Distribution of the lowest oxygen saturation levels measured during cataract surgery for unilateral, bilateral single, and bilateral separate cataract surgery.

17.36 minutes for the first and 98.50 ± 29.06 minutes for the second surgery ($P = .32$) and the surgery time was 29.00 ± 14.68 minutes for the first and 41.50 ± 22.49 minutes for the second surgery ($P = .16$), whereas times for extubation were equal (first: 21.11 ± 6.00 minutes; second: 26.50 ± 13.34 minutes; $P = .28$). The time in the recovery room for the first and second surgery was 69.44 ± 9.50 minutes and 89.38 ± 32.23 minutes, respectively ($P = .096$; Figure 3).

• **SAFETY:** The number of intraoperative complications was not statistically significantly different between the groups ($P = .95$). Iris bleeding was the most common complication during surgery, occurring in 2.70% of the US-Cat, 1.59% of the BS-Cat, and 5.00% of the BT-Cat group. In 3 eyes IOL problems due to torn haptics (US-Cat: 1.35%; BS-Cat: 1.59%) developed during surgery, whereas 2 eyes (US-Cat: 1.35%; BS-Cat: 0.79%) had posterior capsule disruption.

Retreatment was similar in all 3 groups ($P = .10$). The children in the US-Cat group required a mean number of 0.58 ± 1.00 re-surgeries after initial cataract surgery, whereas those in the BS-Cat group required 1.03 ± 2.00 and those in the BT-Cat group 0.45 ± 0.69 re-surgeries. Within the first 3 postoperative months 5.41% of the US-Cat, 15.87% of the BS-Cat, and 5.00% of the BT-Cat group required a re-surgery ($P = .051$). Three to 6 months after cataract extraction, re-surgery was necessary in 10.81% of the US-Cat, 7.94% of the BS-Cat, and 10.00% of the BT-Cat group ($P = .78$). Within 6-12 months after surgery, re-surgery was performed in only 2.70% of the US-Cat, 1.59% of the BS-Cat, and 5.00%of the BT-Cat group ($P = .61$). Most additional interventions were commonly performed after the first postoperative year. The mean time until the first re-surgery was 18.87 ± 19.48 months (range: 0.3-67 months) in the US-Cat group, 27.88 ± 34.02 months (range: 2-97 months) in the BT-Cat group, and 19.20 ± 27.334 months (range: 0.2-95 months) in the BS-Cat group. See Table 4 for detailed information on the postoperative complications for each group.

No evidence for postoperative hypotony or choroidal bleeding was found immediately after initial cataract surgery in any group. A retinal detachment (RD) occurred in 1 patient in the BS-Cat group (0.79%; $P = .07$) 7 months after cataract surgery. Postoperative endophthalmitis was found in 1 eye in the US-Cat group (1.35%) 9 days after initial cataract surgery. One eye (0.79%) in the BS-Cat group developed endophthalmitis 2 days after retreatment owing to VAO. VAO developed equally in all 3 groups (US-Cat: 28.38%; BS-Cat: 23.81%; BT-Cat: 20.00%; $P = .67$). Glaucoma was more common in bilateral cataract (BS-Cat: 15.87%; BT-Cat: 15.00%) than in unilateral cataract (6.76%), but was not statistically significantly different ($P = .20$). Nystagmus was statistically significantly more frequent in the BS-Cat group (49.21%) than

TABLE 3. Detailed Information on the Anesthesia Times and Oxygen Saturation for the Total Study Population and for Each Group Separately

	Total Population	Unilateral Cat	Bilateral Simultaneous Cat	Bilateral Sequential Cat	*P* Value
Total anesthesia time (min)[a]	111.84 ± 38.50	91.62 ± 26.12	123.81 ± 30.11	186.00 ± 42.34	<.001
Total surgery time (min)[b]	34.68 ± 17.00	37.56 ± 15.69	32.33 ± 17.31	37.50 ± 18.67	.087
Extubation time (min)[b]	25.80 ± 17.79	25.16 ± 12.93	27.52 ± 12.91	22.75 ± 11.64	.293
Time in recovery room (min)[b]	99.78 ± 53.26	89.55 ± 45.07	104.78 ± 59.15	70.53 ± 33.99	.024
Oxygen saturation[c]		N = 74	N = 63	N = 10	
No O2 decrease	125 (85%)	65 (88%)	51 (81%)	9 (90%)	
Number of O2 decreases below 93%	17 (15%)	5 (6.76%)	11 (17.46%)	1 (10.00%)	
Mean number of O2 decreases below 93%	0.6 ± 2.2 (range: 0-12)	0.5 ± 2.1 (range: 0-12)	0.98 ± 2.6 (range: 0-12)	0.05 ± 0.2 (range: 0-1)	.34
Mean O2 saturation[d]	96.97 ± 4.15	96.97 ± 4.09	96.56 ± 4.21	98.26 ± 4.11	
Lowest O2 measurement	82	82	83	82	

Statistics: ANOVA.

[a]Total anesthesia time for each surgery of the unilateral and bilateral simultaneous surgery group and added together (first and second surgery) in the bilateral separate-day cataract group.

[b]Total surgery time, extubation time, and time in the recovery room were measured in minutes for each eye.

[c]Analysis of oxygen saturation was based on the number of patients in the bilateral simultaneous cataract surgery and bilateral delayed cataract group.

[d]Mean O2 saturation was average of the lowest measured oxygen levels.

in the other 2 groups (US-Cat: 12.16%; BT-Cat: 20.00%; $P < .001$). However, strabismus was more pronounced in the unilateral cataract group (US-Cat: 68.92%; BS-Cat: 33.33%; BT-Cat: 40.00%; $P < .001$).

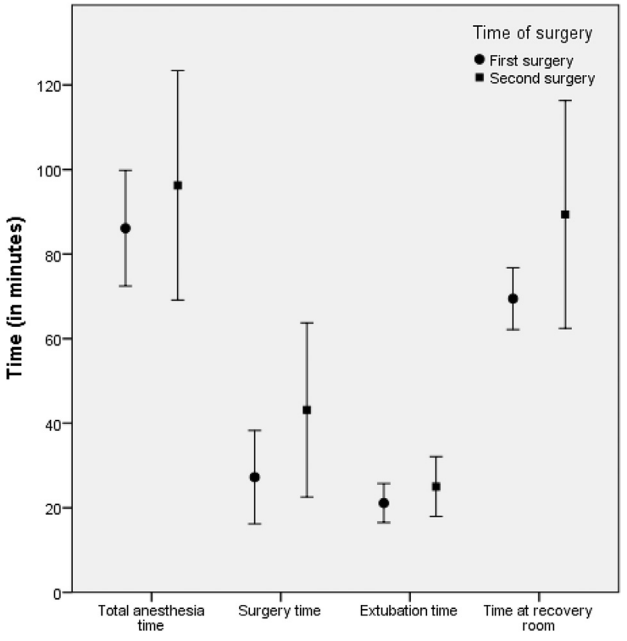

FIGURE 3. Information on the total anesthesia time, surgery time, extubation time, and time in the recovery room for the first and second surgery of the bilateral cataract group receiving surgery on 2 separate days.

DISCUSSION

TO THIS DAY, THERE IS STILL A DEBATE IN THE LITERATURE on the management of bilateral cataract surgery, regarding whether it should be performed simultaneously or not.[11–13] This debate concerns not only adults but also children.[14–16] No standardized guidelines exist for the approach to bilateral cataract. Although local anesthetics are adequate in adults, general anesthesia must be considered when deciding on a 2-step approach in children. A perspective from Smith and associates provides the various exclusion criteria, risks, and advantages and disadvantages to be considered before performing bilateral simultaneous cataract surgery.[17] Although this paper mainly focuses on adult cataract surgery, it importantly recommends postponing a second surgery if an intraoperative complication occurs in the first eye—and this principle should also apply for pediatric cataract.

We have been performing simultaneous surgery in bilateral pediatric cataract at our clinic for 15 years. The main surgical approach in all 3 groups in our study was lensectomy with a primary posterior capsulotomy and anterior vitrectomy. Several studies have recommended a primary lens insertion, as secondary glaucoma is found less often.[18–20] But a rapid increase in axial eye length and subsequent myopic shift was frequently observed in such cases,[21,22] which may necessitate lens replacement in adolescence. In all 3 groups in our study, an IOL was mainly implanted as a secondary procedure around the second year of life, which corresponds to recommendations in the literature.[23,24] The positioning of the lens during the initial

cataract surgery and of the secondary lens implantation did not differ between the groups. However, localization in the initial surgery was mainly in the bag, whereas the lens was placed in the sulcus in secondary implantation.

The analysis of the general anesthesia showed interesting results. Patients who received sequential bilateral cataract surgery had the longest anesthesia time, especially as these patients required general anesthesia 2 times. The general anesthesia time for bilateral simultaneous cataract was also prolonged compared with unilateral cataract, but only by the duration time of the second eye. The duration of surgery and extubation time did not differ statistically significantly between the groups. However, the BS-Cat group spent a significantly prolonged time in the recovery room. Evaluation of the intraoperative oxygen saturation showed similar results for all 3 groups. Most patients did not experience an oxygen decrease below 93%, and the frequency of this rare event was similar between the groups.

The more detailed evaluation of the bilateral sequential cataract surgery showed a high variability in the time in general anesthesia and in the recovery room at the second surgery, whereas the surgery and extubation time did not show a major difference. These results suggest that children are more scared at the second surgery and, therefore, require more anesthetics or feel more pain after surgery and require more pain killers, as described in the literature.[25,26] The evidence is limited by the low number of patients but encourages a prospective study to evaluate these results. However, naturally preoperative anxiety in children and parents can lead to early childhood traumatization, which should be avoided because congenital cataract requires long-term examinations and compliance by the family. In our clinic, children receive rectal or oral sedatives for premedication. Then the child is brought to the operating room, where the anesthesiologist provides gas to achieve further relaxation, following which intravenous access for anesthesia is placed.

Intraoperative complications showed no difference between the groups and were generally rare. No cases of expulsive bleeding or iris root tears were observed. However, occasional iris bleeding or a posterior capsule rupture occurred. In some cases, the haptic tore during lens implantation and as a result the primary IOL was removed and no further attempt made. These results reflect the literature, where iris-related complications such as trauma, bulging, or inadvertent iridotomy or lens-related problems are mainly mentioned.[27–29]

The number of postoperative complications and rate of retreatments showed no difference between the groups. We follow strict guidelines to minimize the risk of bilateral endophthalmitis. After induction of anesthesia, a complete ophthalmic examination including keratometry, ultrasound A- and B-scans for axial eye length, and fundus examination are performed in both eyes. After completion of surgery on the first eye, all devices are replaced, including the phaco set; the surgical site of the second eye is cleaned; and the surgeons change into new clothes and gloves to minimize the possibility of transferring microorganisms. Throughout our follow-up examinations we found no case of bilateral endophthalmitis. However, 9 days after initial cataract surgery, endophthalmitis developed in 1 eye in the unilateral cataract group. This patient received immediate vitrectomy and intravitreal 0.1 mL vancomycin (1.0 mg/ 0.1 mL), 0.1 mL ceftazidim (1 mg/0.1 mL) and 0.1 mL cortisone (Fortecortin 0.4 mg/0.1 mL, Merck Healthcare KGAA). No microorganisms were detected in vitreous samples taken during vitrectomy. Another endophthalmitis developed 2 days after vitrectomy in the BS-Cat group owing to VAO. This patient received a complete vitrectomy and intracameral 0.5 mL cefuroxime (1.0 mg/0.1 mL), 0.5 mL vancomycin (1.0 mg/0.1 mL), and 0.5

TABLE 4. Information on the Postoperative Complications in the Unilateral and Bilateral Cataract Groups

	Unilateral Cat (N = 74)	Bilateral Simultaneous Cat (N = 126)	Bilateral Separate Cat (N = 20)	*P* Value
Number of postoperative complications	59 (79.73%)	95 (75.40%)	14 (70.00%)	.17[a]
Mean number of interventions	0.58 ± 1.00	1.03 ± 2.00	0.45 ± 0.69	.10[b]
Time to retreatment (in months)	18.87 ± 19.48	19.20 ± 27.34	27.88 ± 34.02	.69[b]
Postoperative hypotony	0	0	0	n.a.
Choroidal hemorrhage	0	0	0	n.a.
RD	0	1 (0.79%)	0	.07[a]
Endophthalmitis	1 (1.35%)	0	0	.37[a]
VAO	21 (28.38%)	30 (23.81%)	4 (20.00%)	.67[a]
Glaucoma	5 (6.76%)	20 (15.87%)	3 (15.00%)	.20[a]
Nystagmus	9 (12.16%)	62 (49.21%)	4 (20.00%)	<.001[a]
Strabismus	51 (68.92%)	42 (33.33%)	8 (40.00%)	<.001[a]

RD = retinal detachment; VAO = visual axis obscuration; n.a.= not applicable.
[a]χ^2 test.
[b]ANOVA.

mL cortisone (Dexabene 4 mg, Merckle GmbH, Blaubeuren). Analysis of vitreous samples detected *Streptococcus pneumoniae*. Besides endophthalmitis, also development of Toxic Anterior Segment Syndrome (TASS) has to be kept in mind. In our study we did not experience a TASS case, however to minimize the risk of TASS usage of different lot numbers for intraocular agents such as BSS or viscoelastics should be considered in order to increase safety of simultaneous bilateral cataract surgery furthermore.

Postoperative hypotension or choroidal hemorrhage was not observed in any group. A retinal detachment occurred in 1 eye of the BS-Cat group 7 months after primary cataract surgery. A vitreous strand was cut during vitrectomy at the initial cataract surgery. Careful fundus examinations were performed during the follow-up visits. As soon as RD developed, vitreoretinal surgery, encircling scleral buckling, and vitrectomy with silicone oil tamponade were performed and reattachment was achieved. RD is an infrequent postoperative complication but requires immediate treatment to preserve vision.[30] A VAO developed in 20.00%-28.38% of our patients and showed no statistically significant difference among the groups. Similar rates have been reported in the literature, but the rate of VAO greatly depends on the initial approach.[31–33] Secondary glaucoma was more common in patients with bilateral (BS-Cat: 15.87%; BT-Cat: 15.00%) than unilateral cataract (6.76%). Similar results have been presented in the literature; however, development of glaucoma depends rather on the time point of surgery than on laterality.[34,35] Nystagmus was significantly more frequent in the simultaneous bilateral cataract group (49.21%) than in the other 2 groups (US-CAT: 12.16%; BT-Cat: 20.00%). Nystagmus is generally more common in bilateral cataract because the children cannot maintain fixation.[36] On the other hand, strabismus occurs mainly in unilateral cataract,[37] reflecting our results (US-Cat: 68.92%).

In general, congenital cataract was found in most of our study population. Patients with unilateral cataract were significantly younger at the time of surgery and more likely to demonstrate persistent fetal vasculature as underlying disease. These results, however, reflect numbers from the literature[38] and are unsurprising, as unilateral pediatric cataract surgery is recommended within the first 6-8 weeks of life,[39] whereas the optimal time point for bilateral cataract is between 3 and 6 months of age.

The main limitation of our study was its retrospective nature and that we did not grade the stage of cataract in our patients. However, we present a standardized treatment regimen in pediatric cataract, adhered to by all surgeons at our clinic.

• **CONCLUSION:** With a 15-year experience at our clinic, we can report that bilateral simultaneous cataract surgery is a safe surgical approach for pediatric and juvenile cataract, since no increase of intraoperative as well as postoperative complications was observed. The time under general anesthesia was significantly prolonged in bilateral simultaneous cataract compared with unilateral, but only by the time of the second eye. However, in bilateral sequential cataract surgery the anesthesia time was twice as long. Lensectomy combined with anterior vitrectomy and posterior capsulotomy was the main surgical approach in all children.

FUNDING/SUPPORT: THIS RESEARCH DID NOT RECEIVE ANY SPECIFIC GRANT FROM FUNDING AGENCIES IN THE PUBLIC, COMmercial, or not-for-profit sectors. Financial Disclosures: Ursula Schmidt-Erfurth is consultant for Boerhinger Ingelheim (Vienna, Austria), Genentech (San Francisco, California, USA), Novartis (Basel, Switzerland), and Roche (Basel, Switzerland). The following authors have no financial disclosures: Katharina Eibenberger, Eva Stifter, and Franz Pusch. All authors attest that they meet the current ICMJE criteria for authorship.

REFERENCES

1. Lloyd IC, Ashworth J, Biswas S, Abadi RV. Advances in the management of congenital and infantile cataract. *Eye (Lond)* 2007;21(10):1301–1309.
2. Atkinson J, Anker S, Bobier W, et al. Normal emmetropization in infants with spectacle correction for hyperopia. *Invest Ophthalmol Vis Sci* 2000;41(12):3726–3731.
3. Carden SM, Mathew AA, Good WV. Caught between a rock and a hard place: what is the optimal timing for infantile cataract surgery? *Clin Exp Ophthalmol* 2013;41(7):633–634.
4. Vasavada AR, Nihalani BR. Pediatric cataract surgery. *Curr Opin Ophthalmol* 2006;17(1):54–61.
5. Robbins SL, Breidenstein B, Granet DB. Solutions in pediatric cataracts. *Curr Opin Ophthalmol* 2014;25(1):12–18.
6. Birch EE, Wang J, Felius J, Stager DR Jr, Hertle RW. Fixation control and eye alignment in children treated for dense congenital or developmental cataracts. *J AAPOS* 2012;16(2):156–160.
7. Lambert SR, Lynn MJ, Reeves R, Plager DA, Buckley EG, Wilson ME. Is there a latent period for the surgical treatment of children with dense bilateral congenital cataracts? *J AAPOS* 2006;10(1):30–36.
8. Kuhli-Hattenbach C, Luchtenberg M, Kohnen T, Hattenbach LO. Risk factors for complications after congenital cataract surgery without intraocular lens implantation in the first 18 months of life. *Am J Ophthalmol* 2008;146(1):1–7.
9. Kuhli-Hattenbach C, Fronius M, Kohnen T. Impact of timing of surgery on outcome in children with bilateral congenital cataract. *Ophthalmologe* 2017;114(3):252–258.
10. Nderitu P, Ursell P. Factors affecting cataract surgery operating time among trainees and consultants. *J Cataract Refract Surg* 2019;45(6):816–822.

11. Lansingh VC, Eckert KA, Strauss G. Benefits and risks of immediately sequential bilateral cataract surgery: a literature review. *Clin Exp Ophthalmol* 2015;43(7):666–672.
12. Chang DF. Simultaneous bilateral cataract surgery. *Br J Ophthalmol* 2003;87(3):253–254.
13. Consultation section. Cataract surgical problem. *J Cataract Refract Surg* 1997;23(10):1437–1441.
14. Joseph N, David R. Bilateral cataract extraction in one session: report on five years' experience. *Br J Ophthalmol* 1977; 61(10):619–621.
15. Arshinoff SA, Strube YN, Yagev R. Simultaneous bilateral cataract surgery. *J Cataract Refract Surg* 2003;29(7): 1281–1291.
16. Henderson BA, Schneider J. Same-day cataract surgery should not be the standard of care for patients with bilateral visually significant cataract. *Surv Ophthalmol* 2012;57(6): 580–583.
17. Smith GT, Liu CS. Is it time for a new attitude to "simultaneous" bilateral cataract surgery? *Br J Ophthalmol* 2001; 85(12):1489–1496.
18. Asrani S, Freedman S, Hasselblad V, et al. Does primary intraocular lens implantation prevent "aphakic" glaucoma in children? *J AAPOS* 2000;4(1):33–39.
19. Kugelberg M, Kugelberg U, Bobrova N, Tronina S, Zetterstrom C. After-cataract in children having cataract surgery with or without anterior vitrectomy implanted with a single-piece AcrySof IOL. *J Cataract Refract Surg* 2005; 31(4):757–762.
20. Zetterstrom C, Lundvall A, Kugelberg M. Cataracts in children. *J Cataract Refract Surg* 2005;31(4):824–840.
21. Lambert SR, Lynn MJ, DuBois LG, Cotsonis GA, Hartmann EE, Wilson ME. Axial elongation following cataract surgery during the first year of life in the Infant Aphakia Treatment Study. *Invest Ophthalmol Vis Sci* 2012;53(12): 7539–7545.
22. Magli A, Forte R, Rombetto L. Long-term outcome of primary versus secondary intraocular lens implantation after simultaneous removal of bilateral congenital cataract. *Graefes Arch Clin Exp Ophthalmol* 2013;25(1):309–314.
23. Wilson ME. Intraocular lens implantation: has it become the standard of care for children? *Ophthalmology* 1996;103(11): 1719–1720.
24. Basti S, Ravishankar U, Gupta S. Results of a prospective evaluation of three methods of management of pediatric cataracts. *Ophthalmology* 1996;103(5):713–720.
25. Harris TB, Sibley A, Rodriguez C, Brandt ML. Teaching the psychosocial aspects of pediatric surgery. *Semin Pediatr Surg* 2013;22(3):161–166.
26. Lee JH, Jung HK, Lee GG, Kim HY, Park SG, Woo SC. Effect of behavioral intervention using smartphone application for preoperative anxiety in pediatric patients. *Korean J Anesthesiol* 2013;65(6):508–518.
27. Totan Y, Bayramlar H, Cekic O, Aydin E, Erten A, Daglioglu MC. Bilateral cataract surgery in adult and pediatric patients in a single session. *J Cataract Refract Surg* 2000; 26(7):1008–1011.
28. Dave H, Phoenix V, Becker ER, Lambert SR. Simultaneous vs sequential bilateral cataract surgery for infants with congenital cataracts: visual outcomes, adverse events, and economic costs. *Arch Ophthalmol* 2010;128(8):1050–1054.
29. Repka MX, Dean TW, Kraker RT, et al. Visual acuity and ophthalmic outcomes in the year after cataract surgery among children younger than 13 years. *JAMA Ophthalmol* 2019; 137(7):817–824.
30. Rabiah PK, Du H, Hahn EA. Frequency and predictors of retinal detachment after pediatric cataract surgery without primary intraocular lens implantation. *J AAPOS* 2005;9(2): 152–159.
31. O'Keefe M, Fenton S, Lanigan B. Visual outcomes and complications of posterior chamber intraocular lens implantation in the first year of life. *J Cataract Refract Surg* 2001;27(12): 2006–2011.
32. Hardwig PW, Erie JC, Buettner H. Preventing recurrent opacification of the visual pathway after pediatric cataract surgery. *J AAPOS* 2004;8(6):560–565.
33. Kugelberg M, Zetterstrom C. Pediatric cataract surgery with or without anterior vitrectomy. *J Cataract Refract Surg* 2002; 28(10):1770–1773.
34. Vishwanath M, Cheong-Leen R, Taylor D, Russell-Eggitt I, Rahi J. Is early surgery for congenital cataract a risk factor for glaucoma? *Br J Ophthalmol* 2004;88(7):905–910.
35. Trivedi RH, Wilson ME Jr, Golub RL. Incidence and risk factors for glaucoma after pediatric cataract surgery with and without intraocular lens implantation. *J AAPOS* 2006;10: 117–123.
36. Rabiah PK, Smith SD, Awad AH, Al-garni A, Al-mesfer SA, Al-turkmani S. Results of surgery for bilateral cataract associated with sensory nystagmus in children. *Am J Ophthalmol* 2002;134(4):586–591.
37. Lee SJ, Kim WS. Factors associated with strabismus after cataract extraction and primary intraocular lens implantation in congenital cataracts. *Int J Ophthalmol* 2014;7(3): 522–527.
38. Solebo AL, Russell-Eggitt I, Cumberland P, Rahi JS. Congenital cataract associated with persistent fetal vasculature: findings from IoLunder2. *Eye (Lond)* 2016;30(9):1204–1209.
39. Lambert SR, Plager DA, Lynn MJ, Wilson ME. Visual outcome following the reduction or cessation of patching therapy after early unilateral cataract surgery. *Arch Ophthalmol* 2008;126(8):1071–1074.