Outcomes of early vitrectomy for endophthalmitis after cataract surgery in delta population, Egypt, 2015–2020

Ahmed A. Tabl, Mohamed G. Masoud, Gehad H. Abdelhalim, Marwa A. Tabl

Department of Ophthalmology, Faculty of Medicine, Benha University, Benha, Egypt

Correspondence to Ahmed A. Tabl, MD, Asad Street, Faculty of medicine, Benha University, Benha 13511, Egypt. Tel: +20 122 232 8766; Fax: +20133227518; e-mail: ahmad4Lg@gmail.com, ahmed.tabl@fmed.bu.edu.eg

Received: 26 February 2022
Accepted: 31 March 2022
Published: 8 July 2022

Journal of the Egyptian Ophthalmological Society 2022, 115:59–65

Purpose
To evaluate the outcomes of early pars-plana vitrectomy (PPV) in the management of acute onset endophthalmitis after cataract surgery.
Study design
Retrospective observational study.
Patients and methods
We collected data from 11 patients who were diagnosed as acute infectious endophthalmitis within 6 weeks after cataract surgery, from January 2015 to December 2020 and had undergone early 23-G PPV and were followed up for 3 months. We analyzed factors that may affect prognosis and final visual outcomes.
Results
The mean age was 58±5 years, there was male predominance (72.7%). The mean axial length was 24.76±1.58 mm. The baseline best-corrected visual acuity was 2.3 logMAR and was improved to 1.2 logMAR at the third month ($P<0.001$). Mixed air/fluid intraocular tamponade was used in 63.6% of patients. About half of the cases had positive cultures (54.5%), and the most frequent organism was *Staphylococcus aureus* (66.7%). Retinal detachment was reported in 36.4% of patients. The preoperative factors correlated with final best-corrected visual acuity were posterior vitreous detachment and intraocular tamponade.
Conclusions
Early PPV for acute-onset endophthalmitis after cataract surgery aided in improving final visual outcome and preserving structural and functional integrity of the globe, thus preventing late complications that could affect patients' quality of life. Factors that influence the final visual outcome were intraocular tamponade and posterior vitreous detachment.

Keywords:
cataract surgery, endophthalmitis, pars-plana vitrectomy

J Egypt Ophthalmol Soc 115:59–65

1110-1121

Introduction

Postoperative infectious endophthalmitis is a devastating condition that causes diffuse intraocular inflammation and may lead to blindness. Acute postoperative endophthalmitis (APE) is usually presented within 6 weeks of intraocular procedure and diagnosis is confirmed by clinical examination and by the aid of B-scan ultrasonography [1,2]. The incidence of APE ranges from 0.03 to 0.2% in previous publications [2-5]. It is commonly caused by coagulase-negative *Staphylococcus* and *Streptococcus* species [2,3]. Treatment options for APE are intravitreal antibiotics and/or pars-plana vitrectomy (PPV). The Endophthalmitis Vitrectomy Study (EVS) concluded that immediate 20-G (PPV) did not produce different visual outcomes if the presenting vision is better than perception of light, where intravitreal antibiotics may have a favorable role in such cases [4,5].

Small-gauge PPV improved the surgical outcome of postoperative endophthalmitis significantly in the last two decades, using wide-field viewing systems and the direction toward using silicone oil as an intraocular tamponade that was not used in the EVS study encourage toward seeing new clinical trials investigating the outcome of small-gauge PPV in the early management of APE [6,7]. While using preoperative antibiotics has decreased the rate of APE, it has increased the ratio of drug resistance, which may lead to significant problems in the future [8,9].

Intravitreal vancomycin and ceftazidime are still widely used in the management of APE before PPV with a low incidence of drug resistance and excellent coverage for Gram positive and Gram negative species, respectively [9,10]. Intracameral moxifloxacin is used

DOI: 10.4103/ejos.ejos_14_22

as an intracameral injection at the end of the cataract surgery to reduce the incidence of APE up to threefold according to recent publications with a potent effect against both Gram positive and Gram negative species [11-14].

In this study, we aimed to evaluate the outcome of early PPV in the management of APE after cataract surgery and to analyze the factors related to the final visual outcome in such cases.

Patients and methods

In this single-center retrospective observational study, we collected data from 11 patients who were diagnosed as APE within 6 weeks after cataract surgery, at the Ophthalmology Department, Benha University Hospital, Egypt from January 2015 to December 2020, and had been managed by early 3-port 23-G PPV within 48 h of their confirmed diagnosis using clinical examination and B-scan ultrasonography (Sonomed EZ scan AB-500 plus, Sonomed Escalon, Marcus Avenue, NY 11042, USA). All patients have completed the follow-up for 3 months.

This study followed the principles outlined in the Declaration of Helsinki, and was approved by the Institutional Review Board of Faculty of Medicine, Benha University, Egypt. It was retrospectively registered on ClinicalTrials.gov (identifier, NCT05249413). The inclusion criteria were acute onset endophthalmitis within 6 weeks after primary cataract surgeries; the exclusion criteria were patients diagnosed as endogenous or chronic endophthalmitis, those with a previous history of rupture globe surgery or trauma, and those who did not complete the follow-up period.

Demographic and ophthalmological examination data were collected for all patients as follows: age, sex, and systemic diseases such as diabetes mellitus. Medical and surgical history with preoperative medications, best-corrected visual acuity (BCVA) measured with the Snellen chart and was converted to equivalent logMAR units for statistical analysis. Intraocular pressure was measured by Goldmann applanation tonometry in cooperative patients (Haag-streit holding u.s inc, Kings Mills Road Mason, OH 45040 USA) and by digital palpation in uncooperative ones. Ocular signs of the anterior and posterior segment, the presence of hypopyon, corneal clarity, and the reactions of posterior segments were graded from mild, moderate to severe vitritis according to the fundus view, in which the optic dis and retinal vessels could be seen or not.

Pars-plana vitrectomy operation technique

The 23-G PPV was done by the same surgeon for all cases (A.A.T.) in the operating room with maximum care taken for complete sterilization and under aseptic condition. Surgeries were done using megaTRON S4 (Geuder AG, Hertzstr, Heidelberg, Germany). Vitreous and aqueous samples were collected for culture and sensitivity. The main surgical steps were insertion and check of the infusion line 3.5 mm from the limbus/or insertion into the anterior chamber in cases where there was a doubt about its position due to poor view, aspiration of any fibrin from the anterior chamber and removal of any pupillary membranes trying to maximize view of the posterior segment, core and peripheral vitrectomy. Removal of intraocular lens (IOL) and opening of the posterior capsule was done using the cutter leaving the anterior capsule for supporting future secondary IOL implantation, in cases of partial posterior vitreous detachment (partial-PVD) trimming of the central vitreous leaving vitreous base to avoid creation of iatrogenic breaks, in cases with total PVD removal of all vitreous up to the base was done, in cases with no PVD, just core vitrectomy was done, and staining with triamcinolone acetonide suspension to clear all central vitreous. Intraocular tamponade was chosen according to each case scenario; if no breaks were noted the patient was left on partial air/fluid tamponade, in cases with retinal breaks the patient was left on silicone oil 2000 cs tamponade. All sclerotomies were sutured using vicryl 8-0 to ensure no leakage. Intravitreal ceftazidime 2.25 mg/0.1 ml and vancomycin 1 mg/0.1 ml were injected separately at the end of the surgery 3.5 mm posterior to the limbus, and intraocular pressure was checked digitally.

Statistical analysis

Data management and statistical analysis were done using SPSS, version 28 (IBM, Armonk, New York, USA). Quantitative data were assessed for normality using the Shapiro–Wilk test and direct data visualization methods. According to normality testing, numerical data were summarized as means and SDs or medians and ranges. Categorical data were summarized as numbers and percentages. BCVA was compared between different follow-up times using repeated-measures analysis of variance. All post-hoc analyses were Bonferroni adjusted. Percent change of BCVA at 1 and 3 months was compared according to systemic diseases and intraocular tamponade using the Mann–Whitney *U* test. Fisher's exact test assessed associations between retinal detachment and other parameters. Correlation analyses were done using Spearman's correlation. All statistical tests were two-sided. *P* values of less than 0.05 were considered significant.

Results

General characteristics

The mean age of the studied patients was 58±5 years. There was male predominance (72.7%). The mean axial length was 24.76±1.58 mm. About half of the patients (45.5%) had a systemic disease (Table 1).

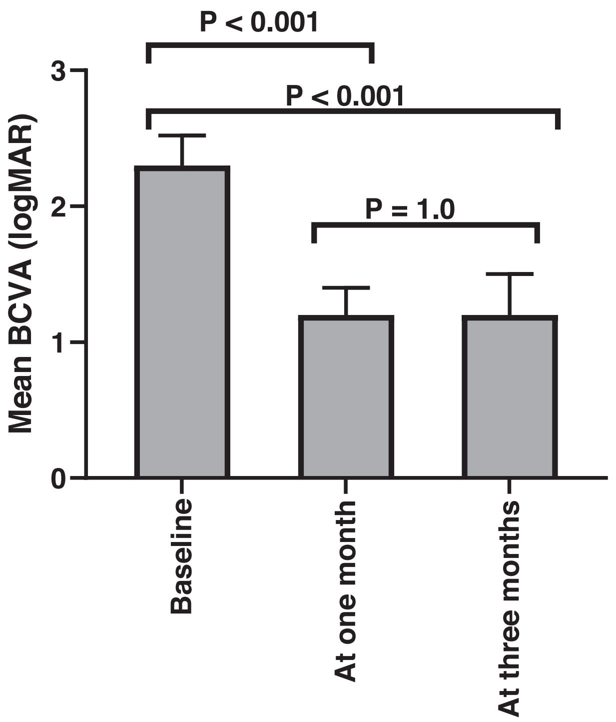
Best-corrected visual acuity at baseline, 1, and 3 months

BCVA showed an overall significant difference between different follow-up times ($P<0.001$). Post-hoc analysis revealed significantly higher BCVA at baseline (2.3 logMAR) than at 1 and 3 months (1.2 logMAR) (Table 2 and Fig. 1).

Clinical findings

Mixed air/fluid intraocular tamponade was used in about two-thirds of the patients (63.6%). About half of the patients had positive cultures (54.5%), and the most frequent organism was *Staphylococcus aureus* (66.7%). Retinal detachment was reported in about one-third of the patients (36.4%), and most of them (75%) had retinal detachment after 1month. About half of the patients had total PVD (54.5%), and one-third (36.4%) had no PVD. Only one patient had partial PVD. One-quarter (27.3%) of the patients had moderate vitritis, while three-quarters (72.7%) had severe vitritis (Table 3).

Figure 1



BCVA at baseline, 1, and 3 months in the studied patients. BCVA, best-corrected visual acuity.

Table 1 General characteristics of the studied patients

Age (years)	
Mean±SD	58±5
Sex [*n* (%)]	
Males	8 (72.7)
Females	3 (27.3)
Axial length (mm)	
Mean±SD	24.76±1.58
Systemic disease	
n (%)	5 (45.5)

Table 2 Best-corrected visual acuity at baseline, 1, 3 months in the studied patients

BCVA (logMAR)	Mean±SD	*P* value
Baseline	2.3±0.22[a]	<0.001*
At 1 month	1.2±0.2[b]	
At 3 months	1.2±0.3[b]	

BCVA, best-corrected visual acuity.
Repeated measures analysis of variance was used. Different letters indicate significant pair. Post-hoc analyses were Bonferroni adjusted.
*Significant

Table 3 Clinical findings in the studied patients

	n (%)
Intraocular tamponade used	
Mixed air/fluid	7 (63.6)
Silicone oil	4 (36.4)
Culture results	
Positive	6 (54.5)
Organism*	
Pseudomonas spp.	1 (16.7)
Staphylococcus aureus	4 (66.7)
Streptococcus pneumonia	1 (16.7)
Retinal detachment	
Present	4 (36.4)
Retinal detachment timing**	
1st month	3 (75.0)
3rd month	1 (25.0)
Preoperative PVD	
No PVD	4 (36.4)
Partial	1 (9.1)
Total	6 (54.5)
Vitritis grading	
Moderate	3 (27.3)
Severe	8 (72.7)

PVD, posterior vitreous detachment.
*Percentages were calculated based on six patients who had positive cultures.
**Percentages were calculated based on four patients who had a retinal detachment.

Correlation between the percent change of best-corrected visual acuity and other parameters

The percent change of BCVA at 1 month showed a significant positive correlation with preoperative PVD grade (r=0.896 and P<0.001). Also, percent change of BCVA at 3 months showed a significant positive correlation with preoperative PVD grade (r=0.625 and P<0.001) (Table 4 and Fig. 2).

Best-corrected visual acuity percent change according to systemic diseases and intraocular tamponade

At 1 and 3 months, percent change of BCVA showed no significant differences regarding systemic diseases (P=0.429 and 0.537, respectively) and intraocular tamponade used (P=0.927 and 0.164, respectively) (Table 5).

Retinal detachment association with intraocular tamponade used and preoperative posterior vitreous detachment grade

Partial or no preoperative PVD was significantly higher in four (100%) cases, who had retinal detachment than those with no retinal detachment (14.3%) (P=0.015). No significant association was reported between retinal detachment and the intraocular tamponade used (P=1.0) (Table 6).

Figure 3 shows an example of a case diagnosed as APE 3 days after primary cataract surgery. Figure 3a shows the preoperative view with cloudy cornea and inflammatory membranes; the baseline BCVA was 1.9 (logMAR). Figure 3b shows intraoperative view after PPV with removal of IOL and air/fluid tamponade. Figure 3c shows improvement of corneal edema on the first follow-up, and Fig. 3d–e shows preoperative and postoperative B-scan ultrasound with

Table 4 Correlation between best-corrected visual acuity percent change and other parameters

	BCVA percent change			
	At 1 month		At 3 months	
	r	*P*	*r*	*P*
Age (years)	0.039	0.91	–0.071	0.836
Axial length (mm)	0.023	0.947	–0.005	0.989
Preoperative PVD	0.896*	<0.001	0.625*	0.04
Preoperative BCVA	0.695*	0.017	0.557	0.07

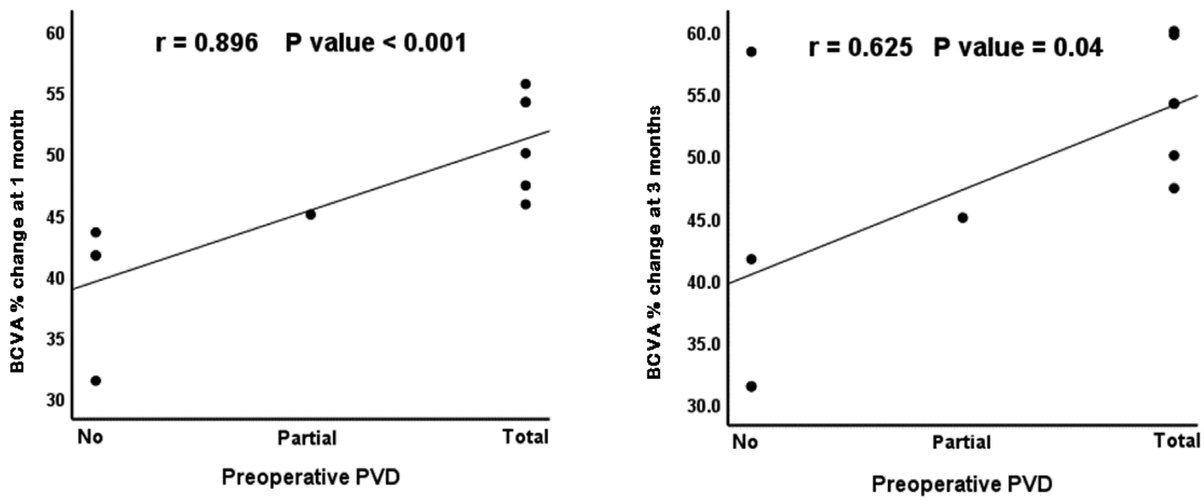
BCVA, best-corrected visual acuity; PVD, posterior vitreous detachment; *r*, correlation coefficient.
Spearman's correlation was used.
BCVA percent change describes the percentage of changes in logMAR to a lower values. Higher percentage means a better improvement in BCVA.
*Significant.

Table 5 Best-corrected visual acuity percent change according to systemic diseases and intraocular tamponade

	Median (range)	*P* value
At 1 month		
Systemic disease		
Yes	50 (31.5–55.6)	0.429
No	44.7 (41.7–54.2)	
Intraocular tamponade		
Mixed air/fluid	45.8 (31.5–55.6)	0.927
Silicone oil	47.5 (41.7–54.2)	
At 3 months		
Systemic disease		
Yes	54.2 (31.5–60)	0.537
No	48.7 (31.5–58.3)	
Intraocular tamponade		
Mixed air/fluid	47.4 (31.5–59.7)	0.164
Silicone oil	56.3 (45–60)	

Mann–Whitney *U* test was used.
Best-corrected visual acuity percent change' describes the percentage of changes in logMAR to lower values. Higher percentage means a better improvement in best-corrected visual acuity.

Figure 2



Correlation between BCVA percent change and PVD degree at 1 and 3 months. BCVA, best-corrected visual acuity; PVD, posterior vitreous detachment.

severe vitritis and total PVD. LogMAR BCVA was improved to 1.0 at 1 and 3 months.

Discussion

In this retrospective observational study, we analyzed the data of 11 patients, who were diagnosed as APE after primary cataract surgery and were managed by a 23-G PPV within 48 h from their diagnosis. The mean timing of the presentation of APE was 5±2 days.

Table 6 Retinal detachment association with intraocular tamponade and preoperative posterior vitreous detachment grade

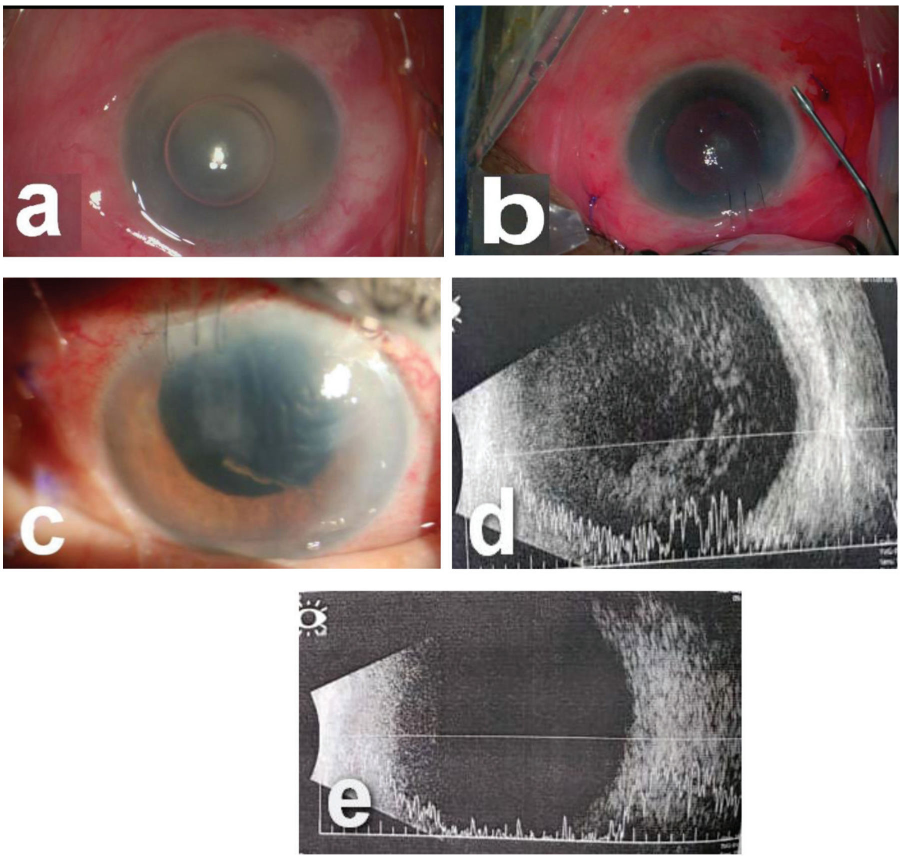
	Retinal detachment		
	Yes	No	*P* value
Intraocular tamponade			
Mixed air/fluid	3 (75.0)	4 (57.1)	1.0
Silicone oil	1 (25.0)	3 (42.9)	
Preoperative PVD			
No or partial	4 (100.0)	1 (14.3)	0.015*
Total	0	6 (85.7)	

PVD, posterior vitreous detachment.
Fisher's exact test was used.
*Significant.

There is no consensus regarding the timing of vitrectomy in cases with APE after cataract surgery. The EVS concluded that vitrectomy should be preserved for cases with only light perception [4]. The advances in posterior segment machines and small-gauge cannulas decrease the incidence of intraoperative complications and encourage for early intervention in cases with APE [6,7].

In a retrospective study conducted by Oshitari *et al.* [15], data of 29 eyes with APE after cataract surgery were analyzed and concluded that visual acuity was improved to 0.5 logMAR or better in 50% of eyes when early vitrectomy was performed. Our results are consistent with them as six of our patients gained a final BCVA of 1.0 logMAR. Better results were also reported in other publications [7,16,17]. On the other hand, a recent study by Soliman *et al.* [18] concluded that similar outcomes were obtained after treatment of APE with intravitreal antibiotics alone in 55 eyes and early vitrectomy within 1 week of presentation in 149 eyes; however, their inclusion criteria were considering any intraocular operation.

Figure 3



Example of a case with APE: (a) preoperative view, (b) immediately after PPV and removal of the IOL, (c) first follow-up view, (d) preoperative B-scan US with total PVD, and (e) postoperative B-scan US. APE, acute postoperative endophthalmitis; IOL, intraocular lens; PPV, pars-plana vitrectomy; PVD, posterior vitreous detachment; US, ultrasound.

In a study conducted by Peng and colleagues, they concluded that the baseline BCVA was one of the prognostic factors correlated with the final visual outcome during 3 months of follow-up. In contrast to the current study, there was a significant correlation between baseline and 1 month BCVA (Table 4). Previous studies have reported significant correlations between the severities of APE and the virulence of the causative organism [19-22]. Vitreous tapping was the most sensitive way in obtaining positive culture results. Gram positive cocci were the most common organisms that were obtained in about 64% out of 82 eyes with APE in a study by Peng *et al.* [20]. Gram negative bacteria were obtained in about 30% of cases in the same study, in which pseudomonas cases showed the worst final visual outcome. In contrast to our study, six cases had a positive culture, in 66.7% of them, *S. aureus* was the causative organism and pseudomonas was found in only one (16.7%) case.

The most significant signs at the time of presentation in this study were hypopyon (91%), fibrin deposition and posterior synechiae (63.6%) and vitritis on B-scan ultrasonography in all cases; these results are similar to other publications [15,18,23].

Regarding PVD in this study, total PVD was found in 54.5%) no PVD in 36.4%, and partial PVD in 9.1%. Cases with total and partial PVD showed a better final visual outcome when compared with cases with no PVD. Also, retinal detachment had occurred in all cases with preoperative absent PVD. Similar results had been reported suggesting that vitreous has an important role for the spread and proliferation of microorganisms in APE [19,23].

In this study, silicone oil tamponade was used in 36.3% of cases, which had a suspicious retinal break or incomplete vitreous removal due to poor intraoperative view, while seven (63.6%) cases were left on a mixture of fluid/air tamponade. During the 3 months of follow-up, retinal detachment had occurred in four (36.3%) cases in which three of them were left on fluid/air tamponade; missed break and proliferative vitreoretinopathy (PVR) were the main causes. Similar results were obtained in a randomized prospective study conducted by Nagpal *et al.* [24], in which 64 eyes that underwent PPV with silicone oil showed better anatomical and functional outcomes when compared with 65 eyes that underwent PPV alone. Also less incidence of retinal detachment was found among silicone-filled eyes (6.2%) when compared with fluid-filled eyes (25.5%). Silicone oil tamponade was reported to have a bactericidal effect [25] and a better final visual outcome in previous reports [16,26].

On the basis of the previous results, prognostic factors that may lead to poor visual outcome were virulent organisms such as *Pseudomonas aeruginosa*, delayed intervention, absence of PVD, and leaving the eye on fluid/air mixture. Similar results were reported in previous studies [19,20,23,27-29]. Chronic intraocular inflammation seems to be responsible for the irreversible retinal cell damage and delayed adverse effects that may occur after PPV for APE such as PVR, retinal detachment, and macular pucker. In this study, retinal detachment due to PVR occurred in 36.3% of cases and macular pucker in 45.4%, which is in accordance with other recent reports [30,31].

This study was conducted in a single tertiary university hospital, the incidence of APE after primary cataract surgeries in the period from January 2015 to December 2020 was 0.1%, and this is in accordance with previously reported range of 0.02–0.2% [32,33].

Preventive measures widely used to decrease the incidence of APE after cataract surgeries are using povidone-iodine, preoperative and postoperative antibiotics, intracameral antibiotics, single-use instrumentations, and cataract machines' cassettes. However, these measures still vary between each center and around the world [34,35]. Intracameral moxifloxacin 0.5% was used at the end of cataract surgery in five (45.4%) cases enrolled in this study.

The limitations in this study are the short-period of follow-up, small sample size, and only studied APE after primary cataract surgeries. Thus, further studies are recommended with a longer follow-up period and a larger sample size to strengthen the outcomes of this study. Authors recommend early PPV in confirmed cases with APE after cataract surgeries and encourage the use of silicone oil endotamponade, especially in cases with no PVD to preserve the functional and anatomical integrity and evade the need for evisceration in such cases.

Financial support and sponsorship
Nil.

Conflicts of interest
There are no conflicts of interest.

References

1 Almeida DR, Miller D, Alfonso EC. Anterior chamber and vitreous concordance in endophthalmitis: implications for prophylaxis. Arch Ophthalmol 2010; 128:1136–1139.

2 Friling E, Lundström M, Stenevi U, Montan P. Six-year incidence of endophthalmitis after cataract surgery: Swedish national study. J Cataract Refract Surg 2013; 39:15–21.

3 Keay L, Gower EW, Cassard SD, Tielsch JM, Schein OD. Postcataract surgery endophthalmitis in the United States: analysis of the complete 2003 to 2004 Medicare database of cataract surgeries. Ophthalmology 2012; 119:914–922.

4 Sousa DC, Jalil A, Patton N, *et al.* Early pars plana vitrectomy in acute endophthalmitis: The Manchester Series. Ophthalmic Surg Lasers Imaging Retina 2022; 53:96–102.

5 Kuhn F, Gini G. Ten years after are findings of the endophthalmitis vitrectomy study still relevant today?. Graefes Arch Clin Exp Ophthalmol 2005; 243:1197–1199.

6 Tan CS, Wong HK, Yang FP, Lee JJ. Outcome of 23-gauge sutureless transconjunctival vitrectomy for endophthalmitis. Eye (Lond) 2008; 22:150–151.

7 Almanjoumi AM, Combey A, Romanet JP, Chiquet C. 23-Gauge transconjunctival sutureless vitrectomy in treatment of post-operative endophthalmitis. Graefes Arch Clin Exp Ophthalmol 2012; 250:1367–1371.

8 Relhan N, Pathengay A, Schwartz SG, Flynn HWJr. Emerging worldwide antimicrobial resistance, antibiotic stewardship and alternative intravitreal agents for the treatment of endophthalmitis. Retina 2017; 37:811–818.

9 Khera M, Pathengay A, Jindal A, Jalali S, Mathai A, Pappuru RR, *et al.* Vancomycin-resistant Gram-positive bacterial endophthalmitis: epidemiology, treatment options, and outcomes. J Ophthalmic Inflamm Infect 2013; 3:46.

10 Reddy AK, Reddy RR, Paruvelli MR, Ambatipudi S, Rani A, Lodhi SA, *et al.* Susceptibility of bacterial isolates to vancomycin and ceftazidime from patients with endophthalmitis: is there a need to change the empirical therapy in suspected bacterial endophthalmitis?. Int Ophthalmol 2015; 35:37–42.

11 Haripriya A, Chang DF, Ravindran RD. Endophthalmitis reduction with intracameral moxifloxacin prophylaxis: analysis of 600 000 surgeries. Ophthalmology 2017; 124:768–775.

12 Rathi VM, Sharma S, Das T, Khanna RC. Endophthalmitis prophylaxis study. Report 1: intracameral cefuroxime and moxifloxacin prophylaxis for the prevention of postcataract endophthalmitis in rural India. Indian J Ophthalmol 2020; 68:819–824.

13 Leung EH, Gibbons A, Stout JT, Koch DD. Intracameral moxifloxacin for endophthalmitis prophylaxis after cataract surgery: cost-effectiveness analysis. J Cataract Refract Surg 2018; 44:971–978.

14 Shenoy P, Goh EJH, Kashikar R, Kohli GM, Sachdeva M, Naman V, *et al.* Impact of prophylactic intracameral moxifloxacin on post-cataract surgery endophthalmitis: data from a tertiary eye care facility in rural India. Int Ophthalmol 2021; 41:2729–2736.

15 Oshitari K. Vitrectomy for endophthalmitis after cataract surgery. Nippon Ganka Gakkai Zasshi 2003; 107:590–596.

16 Pinarci EY, Yesilirmak N, Bayar SA, Sizmaz S, Akkoyun I, Yilmaz G. The results of pars plana vitrectomy and silicone oil tamponade for endophthalmitis after intravitreal injections. Int Ophthalmol 2013; 33:361–365.

17 Tan CS, Wong HK, Yang FP. Epidemiology of postoperative endophthalmitis in an Asian population: 11-year incidence and effect of intracameral antibiotic agents. J Cataract Refract Surg 2012; 38:425–430.

18 Soliman MK, Gini G, Kuhn F, Parolini B, Ozdek S, Adelman RA, Sallam AB European Vitreo-Retinal Society (EVRS) Endophthalmitis Study Group. VISUAL OUTCOME OF EARLY VITRECTOMY AND INTRAVITREAL ANTIBIOTICS IN ACUTE POSTSURGICAL AND POSTINTRAVITREAL INJECTION ENDOPHTHALMITIS: European Vitreo-Retinal Society Endophthalmitis Study Report Two. Retina 2021; 41:423–430.

19 Umazume K, Suzuki J, Usui Y, Wakabayashi Y, Goto H. Possible relation between lack of posterior vitreous detachment and severe endogenous endophthalmitis. J Ophthalmol 2016; 2016:8561379.

20 Peng KL, Kung YH, Tsai HS, Wu TT. Treatment outcomes of acute poptoperative infectious endophthalmitis. BMC Ophthalmol 2021; 21: 384.

21 Callegan MC, Novosad BD, Ramirez R, Ghelardi E, Senesi S. Role of swarming migration in the pathogenesis of *Bacillus* endophthalmitis. Invest Ophthalmol Vis Sci 2006; 47:4461–4467.

22 Lee CS, Hong B, Kasi S, Aderman C, Talcott KE, Adam MK, *et al.* Endophthalmitis Study Group. Prognostic Utility of Whole-Genome Sequencing and Polymerase Chain Reaction Tests of Ocular Fluids in Postprocedural Endophthalmitis. Am J Ophthalmol 2020; 217:325–334.

23 Nishida T, Ishida K, Niwa Y, Kawakami H, Mochizuki K, Ohkusu K. An eleven-year retrospective study of endogenous bacterial endophthalmitis. J Ophthalmol 2015; 2015:261310.

24 Nagpal M, Jain P, Nagpal K. Pars plana vitrectomy with or without silicone oil endotamponade in surgical management of endophthalmitis. Asia Pac J Ophthalmol (Phila) 2012; 1:216–221.

25 Ozdamar A, Aras C, Ozturk R, Akin E, Karacorlu M, Ercikan C. In vitro antimicrobial activity of silicone oil against endophthalmitis-causing agents. Retina 1999; 19:122–126.

26 Azad R, Ravi K, Talwar D, Rajpal Kumar N. Pars plana vitrectomy with and without silicone oil tamponade in post-traumatic endophthalmitis. Graefe's Arch Clin Exp Ophthalmol 2003; 241:478–483.

27 Jeong SH, Cho HJ, Kim HS, Han JI, Lee DW, Kim CG, Kim JW. Acute endophthalmitis after cataract surgery: 164 consecutive cases treated at a referral center in South Korea. Eye (Lond) 2017; 31:1456–1462.

28 Carrim ZI, Richardson J, Wykes WN. Incidence and visual outcome of acute endophthalmitis after cataract surgery – the experience of an eye department in Scotland. Br J Ophthalmol 2009; 93:721–725.

29 Lalwani GA, Flynn HWJr, Scott IU, Quinn CM, Berrocal AM, Davis JL, *et al.* Acute-onset endophthalmitis after clear corneal cataract surgery (1996-2005). Clinical features, causative organisms, and visual acuity outcomes. Ophthalmology 2008; 115:473–476.

30 Wang T, Moinuddin O, Abuzaitoun R, Hwang M, Besirli C, Wubben TJ, Zacks DN Retinal Detachment After Endophthalmitis: Risk Factors and Outcomes. Clin Ophthalmol 2021; 15:1529–1537.

31 Negretti GS, Chan W, Pavesio C, Muqit MMK. Vitrectomy for endophthalmitis: 5-year study of outcomes and complications. BMJ Open Ophthalmol 2020; 5:e000423.

32 Pershing S, Lum F, Hsu S, Kelly S, Chiang MF, Rich WL 3rd, Parke DW 2nd. Endophthalmitis after Cataract Surgery in the United States: A Report from the Intelligent Research in Sight Registry, 2013-2017. Ophthalmology 2020; 127:151–158.

33 Garg P, Roy A, Sharma S. Endophthalmitis after cataract surgery: epidemiology, risk factors, and evidence on protection. Curr Opin Ophthalmol 2017; 28:67–72.

34 Peck TJ, Patel SN, Ho AC. Endophthalmitis after cataract surgery: an update on recent advances. Curr Opin Ophthalmol 2021; 32:62–68.

35 Schmier JK, Hulme-Lowe CK, Covert DW, Lau EC. An updated estimate of costs of endophthalmitis following cataract surgery among Medicare patients: 2010-2014. Clin Ophthalmol 2016; 10:2121–2127.