INFECTIOUS ENDOPHTHALMITIS AFTER GLAUCOMA DRAINAGE IMPLANT SURGERY

Clinical Features, Microbial Spectrum, and Outcomes

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Purpose: To report the clinical features, microbial spectrum, and treatment outcomes of endophthalmitis after glaucoma drainage implant (GDI) surgery.

Methods: Records of patients diagnosed with endophthalmitis after GDI surgery were reviewed. Data on clinical course, microbiological laboratory results, and treatment were analyzed.

Results: Of 1,891 eyes that underwent GDI surgery, 14 eyes (0.7%) developed endophthalmitis. The mean time interval between GDI surgery and diagnosis of endophthalmitis was 2.6 ± 3.2 years (median, 1.3 years; range, 11 days–11.4 years). For initial treatment, 13/14 eyes underwent vitreous tap and injection of intravitreal antibiotics and 1/14 eyes underwent primary pars plana vitrectomy. Three additional eyes underwent pars plana vitrectomy because of deteriorating clinical course. Glaucoma drainage implant erosion was present in 9/14 eyes. All 9 eroded GDIs were surgically removed within a mean of 9 ± 5 days (range 2–29 days) after diagnosis of endophthalmitis. Overall, mean logarithm of the minimum angle of resolution best-corrected visual acuity worsened from 0.7 ± 0.7 (Snellen equivalent 20/100) at baseline to 1.6 ± 1.1 (Snellen equivalent 20/800) at final follow-up (P = 0.005). Mean duration between the onset of symptoms and presentation was significantly longer in patients with decreased final best-corrected visual acuity (>2 Snellen lines) compared to patients with stable final best-corrected visual acuity (6.8 vs. 1.0 days; P = 0.005).

Conclusion: Glaucoma drainage implant–related endophthalmitis is rare and often associated with GDI erosion. Patients who presented earlier after the onset of symptoms had better final visual outcomes. Prompt evaluation and treatment is required, often with removal of the eroded GDI.

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Glaucoma drainage implants (GDIs) are commonly used in the surgical management of glaucoma,[1] and have been validated in randomized controlled trials evaluating efficacy for the treatment of uncontrolled glaucoma.[2–4] Two common GDIs in the United States are the Ahmed glaucoma valve (New World Medical Inc, Rancho Cucamonga, CA) and Baerveldt glaucoma implant (Abbott Laboratories Inc, Abbott Park, IL). The Ahmed Baerveldt Comparison (ABC) study revealed that compared with the Ahmed glaucoma valve, the Baerveldt glaucoma implant had greater intraocular pressure (IOP) reduction and lower rates of reoperation, but a higher incidence of serious complications, including persistent hypotony, explantation of GDI, and loss of light perception.[5] Similar to other intraocular surgeries, GDI surgery is associated with complications including

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corneal decompensation, choroidal effusion, and hyphema.[6,7]

Postoperative endophthalmitis is a rare complication after GDI surgery. The current rate in the literature ranges from 0.00197% to 6.3%.[8–16] Previous studies have suggested that a major risk factor for endophthalmitis after GDI implantation is conjunctival erosion over the tube or reservoir.[8–10,17] Information regarding the clinical course of post-GDI surgery endophthalmitis is limited, as previous studies have been limited to single cases or small case series.

To better describe the nature of endophthalmitis after GDI surgery, we reviewed the clinical course, management, and treatment outcomes of endophthalmitis after placement of an Ahmed glaucoma valve or Baerveldt glaucoma implant at our institution.

Methods

Institutional review board approval from Wills Eye Hospital was obtained for this retrospective study. This research adhered to the tenets of the Declaration of Helsinki and was conducted in accordance with regulations set forth by the Health Insurance Portability and Accountability Act.

A computerized search was conducted for *International Classification of Disease, Ninth Edition (ICD-9)* code for endophthalmitis (360.00–360.04 and 360.19) and current procedure terminology (CPT) code 66,180 for previous GDI surgery. This search included all patients who underwent GDI surgery at Wills Eye Hospital from January 1, 2007 to December 31, 2014.

Patients received either an Ahmed glaucoma valve or Baerveldt glaucoma implant. The key steps of GDI implantation are as follows: An incision was made in the conjunctiva, and blunt dissection was performed. Before Ahmed glaucoma valve implantation, the tube was primed with balanced salt solution to ensure appropriate function of the valve. For a Baerveldt glaucoma implant, a suture was tied at the base of the tube, with or without placement of a stenting suture, and primed with balanced salt solution. Venting slits were made along the tube. Partial thickness scleral sutures were passed to secure the plate. The tube was trimmed to the appropriate length and inserted into the anterior chamber. The tube was secured in place with suture and an overlying patch graft was placed. Viscoelastic material was injected into the anterior chamber according to the surgeon's preference.

A clinical diagnosis of endophthalmitis was based on the presence of vitritis with characteristic clinical features (pain, redness, and/or decreased visual acuity) as diagnosed by a retinal specialist. On diagnosis, all patients were treated with intravitreal antibiotics and/or pars plana vitrectomy (PPV) along with vitreous fluid sampling. The decision to treat using intravitreal antibiotics versus PPV was based on the clinical discretion of the treating retinal specialist. There were no clinical examination or visual acuity guidelines used to determine use of intravitreal antibiotics versus PPV. Endogenous endophthalmitis was ruled out in all cases. Patients with previous trabeculectomy with evidence of blebitis or bleb-related endophthalmitis were excluded from the study.

Patient records were reviewed and the following data were collected: demographic data, type of GDI, location of GDI, lens status, best-corrected visual acuity (BCVA), IOP, and glaucoma medications. Baseline data were defined as the last office visit before a diagnosis of endophthalmitis. Postinfection data were defined as the office visit when a diagnosis of endophthalmitis was made. Clinical course, microbiological laboratory results, management data, including vitreous tap and inject versus PPV, and treatment outcomes were recorded.

The primary outcome measure was final BCVA. Patient data were collected using Snellen visual acuity and converted to logarithm of the minimum angle of resolution (logMAR) equivalents for analysis.[18,19] Patients were divided into 3 groups based on their final BCVA: 1) stable BCVA, defined as final BCVA within 2 Snellen lines of baseline BCVA, 2) decreased BCVA, defined as a loss of final BCVA greater than 2 Snellen lines compared with baseline BCVA, or 3) increased BCVA, defined as improvement of BCVA greater than 2 Snellen lines compared with baseline BCVA. Numerical data were analyzed using a paired student's t-test analysis or Kruskal–Wallis test (SAS Analytics Pro software, Cary, NC). Categorical data were analyzed using Fisher's exact test. A *P*-value less than 0.05 was considered statistically significant.

Results

A database search identified 1,891 eyes that underwent GDI surgery at Wills Eye Hospital from 2007 to 2014. Endophthalmitis was diagnosed in 14 (0.7%) eyes of 14 patients. A summary of patient demographics is detailed in Table 1. Of the 14 eyes, 8 had implantation of a Baerveldt glaucoma implant and 6 had implantation of an Ahmed glaucoma valve. Eight glaucoma surgeons performed implantation of these 14 GDIs. Patch graft materials used during GDI surgery were 9 eyes with Tutoplast (IOP Ophthalmics Inc, Costa Mesa, CA), 2 eyes with VisionGraft (Tissue Banks International, Baltimore, MD), and 2 eyes with

Table 1. Demographic and Clinical Characteristics of 14 Eyes With Infectious Endophthalmitis After GDI Surgery

Case No	Age	Sex	Race	Type of Glaucoma	Type of GDI	Patch Graft Material	Location of Tube	Lens Status	T/I vs. PPV	Intravitreal Injection	Implant Erosion	Implant Removed	Organism Isolated
1	65	F	W	POAG	Baerveldt 250-mm^2	Tutoplast	ST	Aphakic	T/I	V, C	Yes	Yes	None
2	70	F	W	POAG	Baerveldt 350-mm^2	keraSys	ST	Pseudophakic	T/I followed by PPV	V, C	Yes	Yes	*Mycobacterium chelonae*
3	81	M	AA	POAG	Baerveldt 350-mm^2	Tutoplast	ST	Pseudophakic	T/I	V, A	Yes	Yes	Coagulase-negative Staphylococcus
4	75	F	AA	CACG	Baerveldt 350-mm^2	Tutoplast	ST	Phakic	T/I	V, C	Yes	Yes	None
5	50	M	AA	CACG	Baerveldt 250-mm^2	Unavailable	ST	Pseudophakic	PPV	V, C	Yes	Yes	Methicillin-resistant *Staphylococcus aureus*
6	68	F	W	NVG	Baerveldt 350-mm^2	Tutoplast	ST	Phakic	T/I	V, C	Yes	Yes	Methicillin-resistant *Staphylococcus aureus*
7	38	F	W	UG	Baerveldt 350-mm^2	Tutoplast	ST	Phakic	T/I twice	V, C	No	No	None
8	28	F	Other	JG	Baerveldt 350-mm^2	Tutoplast	ST	Phakic	T/I	V, C	No	No	*Streptococcus mitis*
9	78	M	W	POAG	Ahmed FP7	keraSys	IN	Pseudophakic	T/I	V, C	No	No	*Moraxella catarrhalis*
10	82	F	W	POAG	Ahmed FP7	VisionGraft	ST	Pseudophakic	T/I followed by PPV	V, C	Yes	Yes	*Streptococcus mutans*
11	80	M	W	POAG	Ahmed M4	VisionGraft	ST	Pseudophakic	T/I followed by PPV	V, C	Yes	Yes	*Haemophilus influenzae*
12	59	F	A	CACG	Ahmed S2	Tutoplast	ST	Pseudophakic	T/I	V, C	Yes	Yes	None
13	71	M	W	PXG	Ahmed S2	Tutoplast	ST	Pseudophakic	T/I	V, C	No	No	None
14	85	M	W	PXG	Ahmed S2	Tutoplast	ST	Phakic	T/I	V, C	No	No	None

M, male; F, female; W, white; AA, African American; A, Asian; POAG, primary open-angle glaucoma; CACG, chronic angle-closure glaucoma; NVG, neovascular glaucoma; UG, uveitic glaucoma; JG, juvenile glaucoma; ST, superotemporal; IN, inferonasal; T/I, tap and injection of intravitreal antibiotics; V, vancomycin; C, ceftazidime; A, amikacin.

keraSys (IOP Ophthalmics Inc, Costa Mesa, CA). There was 1 eye in which data for type of patch graft material used were not available. Eight eyes were pseudophakic, 5 eyes were phakic, and 1 eye was aphakic. The mean number of previous glaucoma surgeries was 1.0 ± 0.9, and the mean number of all previous intraocular surgeries was 2.0 ± 1.1. The most common glaucoma surgery before GDI implantation was trabeculectomy in 7 eyes. There were 5 eyes without previous glaucoma surgery and 2 eyes without any previous intraocular surgery. No eye underwent subsequent ocular surgery or intravitreal injection in the time period between GDI surgery and diagnosis of endophthalmitis.

Clinical characteristics of all 14 cases at baseline and postinfection are detailed in Table 2. Before infection, mean logMAR BCVA was 0.7 ± 0.7 (Snellen 20/100). At baseline, mean IOP was 13.2 ± 6.6 mmHg (median, 11; range, 5–25 mmHg), and mean number of glaucoma medications was 1.5 ± 1.5 (median, 2; range, 0–4).

The mean time interval between GDI surgery and diagnosis of endophthalmitis was 2.6 ± 3.2 years (median, 1.3 years; range, 11 days–11.4 years). Of the 14 eyes, only 1 eye was diagnosed with endophthalmitis in the immediate postoperative period (<6 weeks after GDI surgery), whereas 13 eyes were delayed in onset (>6 weeks after GDI surgery). Mean number of

Table 2. Clinical Characteristics at Baseline and Postinfection of 14 Eyes With Infectious Endophthalmitis After GDI Surgery

	Baseline			Time Between GDI Surgery and Diagnosis of Endophthalmitis, Years*	At Diagnosis of Endophthalmitis		
Case No	IOP, mmHg	BCVA, logMAR (Snellen)	No. Glaucoma Medications		IOP, mmHg	BCVA, logMAR (Snellen)	Change in BCVA†, logMAR
1	5	0.7 (20/100)	3	7 months	3	3.0 (HM)	2.3
2	9	0.4 (20/50)	2	3.2	8	2.0 (CF)	1.6
3	19	0.0 (20/20)	0	6.3	16	3.0 (HM)	3.0
4	7	0.8 (20/125)	0	5.1	4	1.0 (20/200)	0.2
5	7	0.2 (20/30)	4	11.4	30	3.0+ (LP)	2.8+
6	20	3.0 (HM)	2	11 days	16	3.0 (HM)	0.0
7	10	0.3 (20/40)	0	4 months	16	3.0 (HM)	2.7
8	16	1.0 (20/200)	0	2 months	12	1.3 (20/400)	0.3
9	12	1.3 (20/400)	2	1.2	9	1.3 (20/400)	0.0
10	17	0.3 (20/40)	4	1.3	17	0.3 (20/40)	0.0
11	20	0.3 (20/40)	2	11 months	25	3.0 (HM)	2.7
12	25	0.5 (20/60)	2	5 months	20	1.0 (20/200)	0.5
13	8	0.3 (20/40)	0	3.5	14	2.0 (CF)	1.7
14	10	0.6 (20/80)	0	2.3	12	3.0 (HM)	2.3

	At Diagnosis of Endophthalmitis	1-Year Follow-up		Final Follow-up			
Case No	No. Glaucoma Medications	BCVA, logMAR (Snellen)	Change in BCVA†, logMAR	BCVA, logMAR (Snellen)	Change in BCVA† (logMAR)	Length of Follow-up After GDI Surgery, Years*	Length of Follow-up After Diagnosis of Endophthalmitis, Years*
1	1	1.0 (20/200)	0.3	3.0 (HM)	2.3	3.5	2.9
2	1	3.0+ (NLP)	2.6+	3.0+ (NLP)	2.6+	5.3	2.1
3	0	0.1 (20/25)	0.1	0.2 (20/30)	0.2	10.3	4.0
4	0	0.8 (20/125)	0.0	0.8 (20/125)	0.0	6.2	1.1
5	4	3.0 (HM)	2.8	3.0 (HM)	2.8	14.2	2.8
6	0	3.0+ (LP)	0.0+	3.0+ (LP)	0.0+	3.9	3.9
7	0	0.6 (20/80)	0.3	0.6 (20/80)	0.3	4.7	4.4
8	0	0.4 (20/50)	−0.6	0.4 (20/50)	−0.6	9 months	7 months
9	2	1.5 (20/600)	0.2	1.5 (20/600)	0.2	6.2	5.0
10	1	2.0 (CF)	1.7	2.0 (CF)	1.7	2.6	1.3
11	1	3.0 (HM)	2.7	3.0 (HM)	2.7	2.6	1.7
12	2	1.3 (20/400)	0.8	1.3 (20/400)	0.8	7.6	7.2
13	0	1.0 (20/200)	0.7	1.3 (20/400)	1.0	8.6	5.1
14	0	0.7 (20/100)	0.1	0.7 (20/100)	0.1	4.1	1.8

*Unless otherwise indicated.
†Compared with baseline BCVA.
logMAR, logarithm of the minimum angle of resolution; HM, hand motion; CF, count fingers; LP, light perception.

days between the onset of symptoms and presentation was 4.5 ± 7.6 days (median, 2 days; range, 1–30 days). The most common presenting symptoms were pain (10/14 eyes) and decreased vision (10/14 eyes).

On clinical examination, common features included vitritis (14/14 eyes), hypopyon (7/14 eyes), and anterior chamber fibrin (8/14 eyes) (Figure 1). Glaucoma drainage implant erosion was present in 9 of the 14 cases. All patients were treated for endophthalmitis on the day of diagnosis. For initial treatment, 13 of the 14 eyes underwent vitreous tap and injection of intravitreal antibiotics, and 1 of the 14 underwent primary PPV with intravitreal antibiotics. Vancomycin (1 mg/0.1 mL) and ceftazidime (2 mg/0.1 mL) were injected into 13/14 eyes, whereas vancomycin and amikacin (0.4 mg/0.1 mL) were injected into 1/14 eyes. In 3 eyes, PPV was performed after initial vitreous tap and injection of intravitreal antibiotics because of deteriorating clinical course, which occurred within a mean of 3 days (range, 2–19 days) after vitreous tap. A causative organism was identified in 8 of the 14 eyes (Table 1). The GDI was removed in all cases where erosion occurred (9/9 eyes). On average, the GDI was surgically removed within a mean of 9 ± 5 days (median, 5 days; range, 2–29 days) after endophthalmitis was diagnosed.

The mean follow-up time was 3.1 ± 1.8 years (median, 2.9 years; range, 7 months to 7.2 years) after diagnosis of endophthalmitis. Overall, mean logMAR BCVA worsened from 0.7 ± 0.7 (Snellen 20/100) at baseline to 2.1 ± 1.0 (Snellen count fingers) at diagnosis of endophthalmitis (P = 0.001). Compared with baseline BCVA, mean final BCVA was 1.5 ± 1.1 (Snellen 20/600) at 1-year follow-up and 1.6 ± 1.1 (Snellen 20/800) at final follow-up visit (P = 0.007 and 0.005, respectively). There were 7 of the 14 eyes with final BCVA 20/400 or better. Mean BCVA at final follow-up was 0.9 ± 0.5 (Snellen 20/60) for 5 eyes without GDI explantation and 2.0 ± 1.1 (Snellen count fingers) for 9 eyes with GDI explantation (P = 0.09). Mean IOP remained stable from 13.2 ± 6.6 mmHg preinfection to 14.4 ± 7.4 mmHg at diagnosis of endophthalmitis to 14.6 ± 13.1 mmHg at final follow-up (P = 0.64 and P = 0.71, respectively). Of the 9 eyes with GDI explantation, mean IOP increased from 14.3 ± 7.3 mmHg at baseline to 15.4 ± 9.1 mmHg at diagnosis of endophthalmitis (P = 0.78). The mean IOP at final follow-up was 10.0 ± 6.4 mmHg in the 5 eyes without GDI explantation and 17.2 ± 15.5 mmHg in the 9 eyes with GDI explantation (P = 0.51).

There were 4 eyes with stable final BCVA (≤2 Snellen lines), 1 eye with improved final BCVA (>2 Snellen lines), and 9 eyes with decreased final BCVA (>2 Snellen lines) compared with baseline BCVA. The number of eyes with stable, improved, and worse BCVA at diagnosis of endophthalmitis, 1-year follow-up, and final follow-up compared with baseline is shown in Table 3. Final logMAR BCVA was not different in eyes with Baerveldt glaucoma implant versus Ahmed glaucoma valve (2.0 vs. 1.3 [Snellen count fingers vs. 20/400]; P = 1.00) or presence versus absence of erosion (3.0 vs. 1.3 [Snellen hand motion vs. 20/400]; P = 0.35). In cases with GDI erosion, the number of days from diagnosis of endophthalmitis to GDI removal was not related to final BCVA (P = 0.39). Mean duration between the onset of symptoms and presentation was significantly longer in patients with decreased final BCVA (>2 Snellen lines) compared with patients with stable final BCVA (6.8 vs. 1.0 days; P = 0.005).

Discussion

In this study, we retrospectively reviewed the clinical course, management, and treatment outcomes

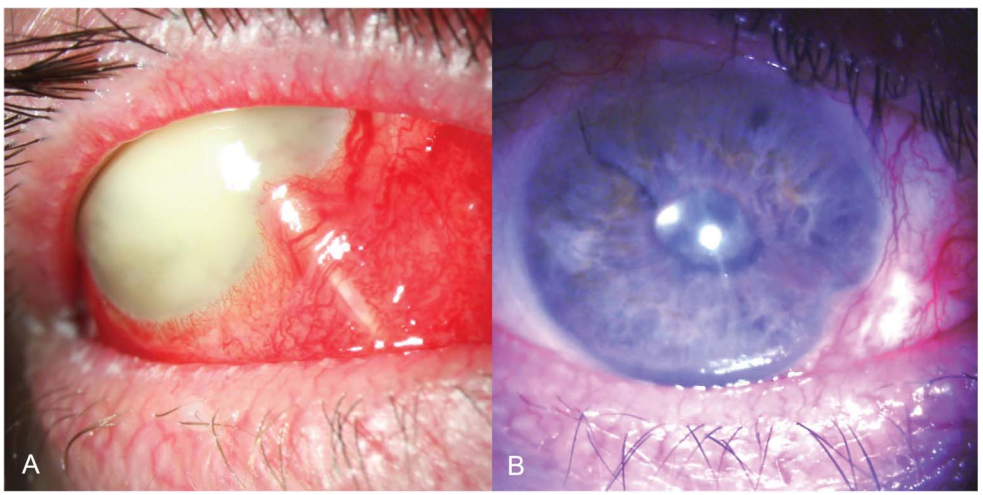

Fig. 1. A. Late-onset infectious endophthalmitis 12 years after initial GDI surgery. **B.** The same eye 6 weeks after PPV with tube shunt explantation.

Table 3. Change in BCVA at Diagnosis of Endophthalmitis, 1-Year Follow-up, and Final Follow-up Compared With Baseline

	At Diagnosis of Endophthalmitis Compared With Baseline, n (%)	1-Year Follow-up Compared With Baseline, n (%)	Final Follow-up Compared With Baseline, n (%)
Stable BCVA*	4 (29)	5 (36)	4 (29)
Decreased BCVA†	10 (71)	8 (57)	9 (64)
Improved BCVA‡	0 (0)	1 (7)	1 (7)

*Final BCVA within 2 Snellen lines of baseline BCVA.
†Decreased BCVA greater than 2 Snellen lines compared with baseline BCVA.
‡Improved BCVA greater than 2 Snellen lines compared with baseline BCVA.

of patients with endophthalmitis after GDI surgery. To the best of our knowledge, this study is the largest case series of endophthalmitis after GDI surgery to date.

Previous studies have reported on the incidence and outcomes of GDI-related endophthalmitis. Endophthalmitis after GDI surgery ranges between 0.00197% and 6.3% based on case reports or small case series.[8–16] After developing GDI-related endophthalmitis, most patients have poor visual outcomes. In a retrospective study of 542 eyes that underwent Ahmed glaucoma valve implantation during a 9-year review period, Al-Torbak et al[8] reported 9 cases of GDI-related endophthalmitis and found that no patient achieved a final visual acuity better than 20/200.

Previous studies have also described the microbial spectrum and time course of post-GDI endophthalmitis. Both gram-positive and gram-negative organisms have been identified in cases of GDI-related endophthalmitis.[8,9] A retrospective study with 11 cases of GDI-related endophthalmitis by Al Rashaed et al[9] found that the most commonly cultured pathogens were Streptococcus species and *Haemophilus influenzae*. Although GDI-related endophthalmitis can occur at any time after GDI surgery, previous studies have noted that endophthalmitis is often delayed in onset.[8–10,20,21] Late endophthalmitis associated with GDI has been related to tube erosion,[8–10,17] which may occur months to years after surgery. Al-Torbak et al found that conjunctival erosion over the tube was present in six of the nine cases, and conjunctival erosion was significantly associated with development of endophthalmitis. Presumably, once the tube is exposed, it likely serves as a conduit for host flora to travel from the ocular surface into the eye. Covering the anterior portion of the tube with a patch graft may be able to help reduce the rate of erosions.[22]

In our series, the rate of endophthalmitis was 0.7%, which was within the rates reported by previous studies.[8–16] Similar to previous reports on endophthalmitis after GDI surgery,[8–10] our series had poor visual outcomes after endophthalmitis. The mean final logMAR BCVA was 1.6 ± 1.1 (Snellen 20/800). Seven of the 14 eyes had BCVA 20/400 or better. There are similar visual outcomes in patients with endophthalmitis after filtering surgery. The proportion of patients with visual acuity 20/400 or better after bleb-related endophthalmitis was reported to be 22% to 57%.[23–27] However, in another study with a 5-year follow-up of bleb-related infections, only 4 of the 21 eyes had decreased visual acuity.[28]

Our series included 13 cases of GDI-related endophthalmitis that were delayed in onset, similar to previous reports.[8–10,20,21] Our study confirmed microbiological growth in 8 of the 14 cases. The number of culture-positive cases is similar to previous studies of postoperative endophthalmitis after GDI surgery, cataract surgery, and bleb filtering surgery.[8,9,29,30] The most commonly isolated organisms in our series were Staphylococcus species in 3 cases and Streptococcus species in 2 cases. Previous studies have noted that Streptococcus is the most commonly isolated species,[8,9] but Staphylococcus species has also been shown to be frequently involved in GDI-related endophthalmitis.[10,17] In other studies of endophthalmitis after cataract surgery or bleb filtering procedures, Streptococcus was the most commonly isolated species, followed by Staphylococcus species.[23,29,30] There may be variations in organism distribution between studies because of the rarity of GDI-related endophthalmitis and sampling bias. It is not surprising that the species isolated are normal bacterial flora found in the conjunctiva. These organisms are likely to cause late-onset endophthalmitis through migration from the periocular surface into the eye in the setting of GDI erosion.

Glaucoma drainage implant erosion remains a significant risk factor for post-GDI endophthalmitis. A meta-analysis of 3,255 eyes found that the overall incidence of GDI erosion was approximately 2.0 ± 2.6% with an average exposure of 0.09 ± 0.14% per month.[31] At our center, Trubnik et al[32] found GDI erosion in 28 of the 339 eyes (8.3%). Although all patients in our series underwent patch grafting at initial

GDI surgery to help prevent erosion, 9 of the 14 cases had erosion present at the time of diagnosis of endophthalmitis. Other authors have reported successful treatment of infection using intravitreal antibiotics while leaving the GDI in place.[33] However, all GDIs with erosion were explanted in our series. Once the infectious organism has seeded the GDI, it may be difficult to clear the infection without removing the infected conduit. Glaucoma drainage implant was surgically removed within a mean of 9 days after erosion was first detected. The number of days to tube removal did not affect final BCVA. Our results showed that explantation of the GDI did not result in inadequate IOP control, as final IOP was similar in eyes with GDI explantation compared with eyes without GDI explantation. Poor visual outcomes may be secondary to necrosis from infection. However, eyes in our study had significant glaucoma, and fluctuations in IOP may have also contributed to poor visual outcomes. Efforts to prevent tube erosion should be paramount, as is prompt GDI revision in cases where erosion is identified, to prevent post-GDI endophthalmitis.

Regarding management strategy, our study did not compare BCVA for eyes that underwent vitreous tap and intravitreal antibiotic injection versus PPV as initial treatment. Only one eye underwent immediate PPV at the discretion of the treating retinal specialist given clinical severity (light perception vision with 100% hypopyon and dense vitritis on B-scan ultrasonography) and 3 eyes underwent PPV an average of 3 days after vitreous tap. Because of small sample size in each group, we cannot definitely compare outcomes to make treatment recommendations. Ideally, further research in the form of a randomized control trial should be performed to determine the optimal management strategy for GDI-related endophthalmitis; however, it is unlikely that such a study will be conducted given the low incidence of disease. Although our study does not directly compare management strategies, endophthalmitis is associated with poor visual outcomes and aggressive management with vitreous tap and injection of antibiotics, explantation of the eroded GDI, and possibly vitrectomy, is required.

There was a longer duration between the onset of symptoms and presentation between patients with decreased final BCVA compared with patients with stable final BCVA (6.8 vs. 1.0 days; $P = 0.005$). Patients who presented sooner (less than 2 days) after the onset of symptoms had better visual outcomes. These findings emphasize the significance of regularly educating patients about signs and symptoms of endophthalmitis, even years after initial GDI surgery.

This study has several limitations, many of which are inherent to its retrospective nature. A major limitation of our study was the small sample size, making comparisons between small subgroups and broad recommendations difficult. In addition, given that management was largely homogenous (GDI explantation in all cases of erosion and 13 of the 14 eyes receiving initial vitreous tap and injection of antibiotics), comparison among different treatments has limited value.

In conclusion, endophthalmitis is a rare but devastating complication after GDI surgery that is often delayed in onset. Most cases were associated with tube erosion. Patients who presented sooner after the onset of symptoms had ultimately better visual outcomes. Given poor long-term visual prognosis in general, prompt treatment is advised, including vitreous tap and injection of intravitreal antibiotics and/or PPV, with the removal of eroded GDI.

Key words: endophthalmitis, glaucoma drainage implant, Ahmed, Baerveldt, tube shunt.

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