EXTENDED REPORT

Endophthalmitis associated with the Ahmed glaucoma valve implant

A A Al-Torbak, S Al-Shahwan, I Al-Jadaan, A Al-Hommadi, D P Edward

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Correspondence to: Abdullah A Al-Torbak, MD, FRCS, King Khaled Eye Specialist Hospital, PO Box 7191 Riyadh 11462, Saudi Arabia; atorbaq@health.net.sa

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Aim: To investigate the rate, risk factors, clinical course, and treatment outcomes of endophthalmitis following glaucoma drainage implant (GDI) surgery.

Methods: A computerised relational database search was conducted to identify all patients who were implanted with Ahmed glaucoma valve (AGV) and developed endophthalmitis following surgery at the King Khaled Eye Specialist Hospital in Riyadh, Saudi Arabia, between 1 January 1994 and 30 November 2003. Only medical records of the patients who developed endophthalmitis were retrospectively reviewed.

Results: 542 eyes of 505 patients who were on active follow up were included in the study. Endophthalmitis developed in nine (1.7%) eyes; the rate was five times higher in children than in adults. Delayed endophthalmitis (developed 6 weeks after surgery) occurred in eight of nine eyes. Conjunctival erosion overlying the AGV tube was present in six of nine eyes. Common organisms isolated in the vitreous included *Haemophilus influenzae* and *Streptococcus* species. Multiple regression analysis revealed that younger age and conjunctival erosion over the tube were significant risk factors associated with endophthalmitis.

Conclusion: Endophthalmitis is a rare complication of GDI surgery that appears to be more common in children. Conjunctival dehiscence over the GDI tube seems to represent a major risk factor for endophthalmitis. Prompt surgical revision of an exposed GDI tube is highly recommended.

Glaucoma drainage implants (GDIs) have become an important method of controlling intraocular pressure (IOP) in patients with refractory glaucoma. Surgery with GDIs is associated with similar operative and postoperative complications that may occur after filtering surgery such as hypotomy, hyphaema, cataract, corneal decompensation, and failure to control IOP.[1] In addition, several unique complications may develop with GDIs related to the presence of an implanted foreign body such as diplopia[2] and transcorneal tube erosion.[3]

Although endophthalmitis is a rare complication after GDI surgery, the exact rate is not known.[4] Several retrospective studies of GDIs have included a single case or a few cases of endophthalmitis resulting in rates ranging from 0.8% to 6.3%.[5–19]

We report the rate, clinical course, risk factors, and treatment outcomes of endophthalmitis associated with Ahmed glaucoma valve implant (New World Medical, Rancho Cucamonga, CA, USA) at one institution.

METHODS

This study was reviewed and approved by the institutional review board of the King Khaled Eye Specialist Hospital (KKESH). A computerised relational database search was conducted to identify all patients who were implanted with Ahmed glaucoma valve (AGV), surgery at the King Khaled Eye Specialist Hospital in Riyadh, Saudi Arabia, between 1 January 1994 and 30 November 2003. This group of patients was further screened to identify those who were on active follow up and had no concurrent procedures performed with the AGV implant. Patients who developed AGV related endophthalmitis in this group were included in this study. Only medical records of the patients who developed endophthalmitis were retrospectively reviewed. Patients identified were divided into adult and paediatric groups; those below 18 years of age were considered children as defined by the World Health Organization.

Multiple surgeons performed the AGV implant procedures. In the majority of cases a limbal based conjunctival flap was created between superior and lateral recti muscles. The valve plate was secured 8–10 mm posterior to the limbus using an 8–0 non-absorbable suture. The tube was cut to an appropriate length and inserted into the anterior chamber through a 23 gauge needle track and covered by either donor sclera, dura, or pericardial patch graft. Autologous scleral patch graft was not used in any of the procedures. Patients younger than 6 months with an axial length less than 22 mm received the paediatric model (AGV; model S1). Otherwise the adult model (AGV; model S2) was used. The AGV was the only glaucoma valve implant used at KKESH during the period of the study and other glaucoma drainage implants were not available for comparison.

Based on the chart review, data of patients who developed endophthalmitis following AGV implant surgery were collected and reviewed. This included demographic information, clinical settings, pertinent operative and preoperative data, culture sites, and type of organisms. In addition, treatments and treatment outcomes were also noted. Diagnosis of endophthalmitis was based on clinical findings and ultrasonography.

A multiple regression analysis was performed to determine how the variables of age (above and below 18 years of age) and the presence or absence of conjunctival erosion related to endophthalmitis. Statistical analyses were conducted using GB STAT 10.0 (Dynamic Microsystems, Inc, Silver Spring, MD, USA).

RESULTS

The relational database search identified 102 patients (113 eyes) under age 18 years (paediatric), and 403 patients (429 eyes) over age 18 years (adult) who underwent AGV surgery

Abbreviations: AGV, Ahmed glaucoma valve; GDI, glaucoma drainage implant; IOP, intraocular pressure

Table 1 Demographics, clinical settings, culture sites, and type of organism

Patient No	Age (years)	Sex	Glaucoma diagnosis	Mitomycin C use	Implant location	Type of patch graft	Interval (days*)	Duration (days†)	Presenting visual acuity	Tube erosion	Culture site	Organism(s)
1	0.8	F	Congenital glaucoma	Yes	IT	Sclera	63	7	NR	No	AC, VIT	*Haemophilus influenzae*, *Streptococcus pneumoniae*
2	1	F	Congenital glaucoma	Yes	ST	Pericardium	30	5	NR	Yes	AC, VIT	*Streptococcus pneumoniae*
3	1	F	Congenital glaucoma	Yes	IT	Dura	104	2	NR	Yes	VIT	No growth
4	2	M	Congenital glaucoma	Yes	ST	Dura	270	5	LP	No	VIT	*Streptococcus pneumoniae*
5	6	F	Secondary glaucoma	Yes	ST	Dura	210	2	CF	Yes	AC, VIT	*Haemophilus influenzae*
6	43	M	Secondary glaucoma	Yes	ST	Sclera	180	4	CF	Yes	AC, VIT	No growth
7	60	F	Secondary glaucoma	Yes	SN	Sclera	300	1	HM	Yes	VIT	*Streptococcus agalactiae*
8	78	M	Secondary glaucoma	No	ST	Dura	306	2	CF	No	VIT	*Streptococcus mitis*
9	63	M	Primary glaucoma	No	ST	Dura	330	5	Poor LP	Yes	VIT	*Pseudomonas aeruginosa*

AC, anterior chamber; CF, counting fingers; F, female; HM, hand movements; LP, light perception; IT, inferotemporal; M, male; NR, not recorded since patient was sedated; SN, superonasal; ST, superotemporal; VIT, vitreous.
*Interval between AGVI surgery and endophthalmitis diagnosis; †duration of symptom before diagnosis of endophthalmitis.

and were on active follow up. Endophthalmitis was detected in nine (1.7%) of these eyes (table 1); five (4.4%) in the paediatric age group and four (0.9%) in the adult age group. The mean age of all patients at the time of endophthalmitis was 28.3 years (range 0.8–78 years); 2.2 years (range 0.8–6 years) and 61 years (range 43–78 years) in the paediatric and adult age groups, respectively. Types of glaucoma identified were congenital in four of nine eyes, secondary in four of nine eyes, and primary open angle in one of nine eye. The mean number of previous glaucoma surgeries was 1.1 (range 0–2). One eye had no previous glaucoma surgery, six eyes had one procedure, and two eyes had two procedures. The most common previous glaucoma surgery was trabeculectomy with antimetabolite (mitomycin C was used as an adjunct in eight of nine eyes). Three eyes received the paediatric model and six eyes received the adult model of the AGV respectively. No patient had more than one implant in these nine eyes. No glaucoma surgery had been performed after the initial implant surgery. Seven of the nine eyes had received mitomycin C during implant surgery. Owing to the dense corneal opacities and/or advanced glaucoma, none of the patients achieved a pre-infection visual acuity of better than 20/100. One child had history of conjunctivitis 10 days before development of endophthalmitis.

The median interval between AGV implant surgery and diagnosis of endophthalmitis was 206 days (range 63–330 days). Delayed onset endophthalmitis (developed 6 weeks after surgery) occurred in eight of nine eyes, and the infection developed in one of nine eye within the first few weeks of surgery.

The median duration between onset of symptoms and presentation for diagnosis and treatment at KKESH was 3.7 days (range 1–7 days). All patients were treated for endophthalmitis on the day of presentation (table 2). Conjunctival erosion over the tube was noticed in six of nine eyes and four of six eyes had a Siedel positive leak. The site of the conjunctival erosion was near the limbus in three of six eyes, and in two of six eyes the conjunctival erosion was away from the limbus where the erosion extended through the patch graft to expose the tube. In one of six eyes, the site of the conjunctival erosion was at the tube plate junction. Purulent discharge was observed in the area of the erosion in two eyes.

Vitreous cultures were positive for the infecting organism(s) in seven of nine eyes and negative in two of nine eyes. *Hemophilus influenzae* and *Streptococcus pneumoniae* were isolated from the culture sites in children. In adults, organisms causing AGV related endophthalmitis included *Streptococcus* species and *Pseudomonas aeruginosa*.

In this series, one of nine eye was initially treated with evisceration because of severe infection with pain and no visual potential. Three of nine eyes underwent pars plana vitrectomy plus intravitreal antibiotics injection. In the remaining five of nine eyes, intravitreal antibiotics alone were administered during the vitreous tap. Intravitreal dexamethasone was administered in two eyes. The intraocular antibiotic regimen used in this series consisted of vancomycin and either an aminoglycoside or ceftazidime. Pars plana vitrectomy with intravitreal antibiotics injection did not appear to have an impact on the final visual acuity.

Multiple regression analyses revealed younger age (<18 years of age; $p<0.05$) and conjunctival erosion over tube ($p<0.01$) were significantly associated with the occurrence of endophthalmitis. The glaucoma drainage implant was removed at the time of intravitreal injection in four of nine eyes and left intact in five of nine eyes. Removal or retention of the AGV did not appear to influence the final visual acuity.

Table 2 Treatment performed and clinical outcomes

Patient No	Tap/injection *v* pars plana vitrectomy/ injection	Intravitreal injections	Implant removed	Sensitivity of organism	Pre-infection Visual acuity	Pre-infection IOP (mm Hg)	Pre-infection Medications	Follow up (months)	Post-infection Visual acuity	Post-infection IOP (mm Hg)	Post-infection Medication
1	PPV	V, A	No	V	HM	14	2	4	NLP	0	0
2	Tap	V, C	Yes	V, B	FL	18	0	9	NLP	5	0
3	Tap	V, A	Yes	_	FO	15	1	26	CF	11	3
4	Tap	V, A	No	V, E	FO	21	1	18	HM	9	2
5	PPV	V, C, D	No	C, CE	20/100	20	1	14	LP	16	1
6	Tap	V, A	No	_	20/125	20	1	17	20/200	18	2
7	Tap	V, A, D	Yes	V, P	CF	10	2	13	HM	15	2
8	PPV	V, C, D	No	V, B	20/100	09	2	19	20/200	14	2
9	Primary evisceration	NA	Yes	T	CF	20	2	6	NLP	0	0

A, amikacin; AM, ampicillin; B, bacitracin; C, ceftazidime; CE, cefaclor; CF, counting fingers; D, dexamethazone; E, erythromycin; FL, follow light; FO, follow objects; HM, hand movements; LP, light perception; NA, not applicable; NLP, no light perception; P, penicillin; T, tobramycin; V, vancomycin.

Three of nine patients had a final visual acuity outcome of no light perception and six of nine patients attained a final visual acuity of light perception or better. None achieved a final visual acuity of better than 20/200.

DISCUSSION

Glaucoma drainage implants (GDIs) have become increasingly useful in surgical management of glaucoma that is refractory to standard filtering surgery. Although intraocular pressure may be successfully controlled, postoperative complications do occur. This large series from a single institution highlights the clinical features, risk factors, and outcomes that have been previously only presented in small case series.

In our series the overall rate of endophthalmitis was 1.7%. We compared this rate with an analysis of endophthalmitis rates following all shunts in the literature. It appeared that the endophthalmitis rate in this series was fairly consistent with that reported in the literature (mean 2.0%; range 0.8%–6.3%;[5–19 20] see table 3). This suggests that the type of shunt device implanted does not influence the risk of endophthalmitis. However, the rate of endophthalmitis following AGV implant surgery in the paediatric age group was five times higher than adults in our study (4.4% *v* 0.9%). Multiple regression analysis confirmed that younger age (<18 years) was a significant risk factor for endophthalmitis. Interestingly, the rate of endophthalmitis in children appeared to parallel the rate of tube exposure in paediatric shunts (10–13%),[17 21] which was five times higher than the rate reported for glaucoma implants in adults (0–2%).[9 22]

Our series suggest that most cases (eight of nine) of endophthalmitis secondary to AGV implant surgery were delayed in onset (6 weeks after surgery). This concurs with isolated cases in series or individual case reports which also suggested most endophthalmitis following GDIs were delayed in onset.[4 23–25] However, isolated cases of early endophthalmitis associated with GDIs have also been reported. Perkins[26] reported early postoperative endophthalmitis following placement of a Molteno implant in an adult patient. In our series the patient with early endophthalmitis was a child. Moreover, endophthalmitis has also been described after tube repositioning[27] and needling.[28] Such presentations were not seen in our series.

Tube exposure following conjunctival erosion in AGV implant appeared be a major risk factor for the development of endophthalmitis as shown by regression analysis in our series. Other series have also reported conjunctival tube erosion without risk analysis. Gedde *et al*[4] reported four cases of endophthalmitis associated with GDIs. In their series all cases were associated with conjunctival erosion overlying the tube. Recently, Morad *et al*[17] reported three cases of endophthalmitis following AGV. Two of these cases were noted to have tube exposure at the time of presentation. In our series, six of nine eyes were found to have conjunctival erosion over the tube at the time of presentation. The conjunctival erosion was at the limbus in three of six eyes,

Table 3 Endophthalmitis associated with GDIs reported in various studies

Source	Study date	Number of cases	Number of endophthalmitis cases	% of endophthalmitis	Type of implant
Munoz *et al*[5]	1991	53	1	1.9	Molteno
Hill *et al*[6]	1991	70	1	1.4	Molteno
Chihara *et al*[7]	1992	16	1	6.3	White pump
The Krupin Eye Valve Filtering Surgery Study Group[8]	1994	50	1	2	Krupin valve with disc
Lloyd *et al*[9]	1994	73	1	1.4	Baerveldt
Perkins *et al*[10]	1995	21	1	4.8	Molteno
Price and Wellemeyer[11]	1995	76	1	1.3	Molteno
Law *et al*[12]	1996	38	1	2.6	Molteno
Nguyen *et al*[13]	1998	107	1	0.9	Baerveldt
Djodeyre *et al*[14]	2001	35	1	2.6	Ahmed
Krishna *et al*[15]	2001	65	2	3.1	Baerveldt
Taglia *et al*[16]	2002	27	1	3.7	Molteno
Morad *et al*[17]	2003	60	3	5	Ahmed
Seah *et al*[18]	2003	124	1	0.8	Baerveldt
Tsai *et al*[19]	2003	70	1	1.4	Baerveldt
Present study	2004	542	9	1.7	Ahmed
Total		1427	27	1.9	

and at other locations in others. It did not appear to be related to the conjunctival incision line which was a few millimetres away from the limbus in the majority of the cases. Reasons for conjunctival erosion over patch grafts and tube are not totally clear and are possibly multifactoral. Most patients had multiple previous conjunctival surgeries with exposure to antimetabolites; in addition seven of nine eyes had received mitomycin C during implant surgery and this may have played a part in the erosion of the conjunctiva. The rate of tube erosion through the conjunctiva can be reduced by covering the anterior portion of the tube by a patch graft. Different tissues have been utilised as a patch graft and these include sclera,[29] dura mater,[30] fascia lata,[31] pericardium,[32] and autologous sclera.[33] Conjunctival erosion overlying the tube in our series occurred despite the use of a dura mater patch graft in five eyes, a donor sclera patch graft in three eyes, and a pericardial patch graft in one eye. The eroded conjunctiva surrounding the tube probably serves as a conduit by which normal flora may pass from the ocular surface into the eye. Given the increased risk of endophthalmitis, we recommend prompt surgical revision in all cases in which there is an exposed tube of a GDI.

Organisms causing endophthalmitis following GDIs in children are *Haemophilus influenzae*, *Streptococcus pneumonia* or both. In our series, cultures revealed *Streptococcus pneumonia* in two eyes and *H influenzae* in one eye. Both organisms were cultured from one eye (patient 4). Gedde *et al*,[4] and Al-Torbaq and Edward[24] reported *H influenzae* caused endophthalmitis following GDIs in two separate paediatric patients. This is not surprising as *H influenzae* and *Streptococcus pneumonia* are part of the normal bacterial flora of the conjunctiva and upper respiratory tract, and a common cause of infection in both tissues.[34 35] In adults, organisms causing GDI related endophthalmitis include coagulase negative and coagulase positive *Staphylococcus species*, *Streptococcus pneumonia*, and *Pseudomonas aeruginosa*.[4 12 26] In our series other Gram positive organisms including *Streptococcus agalactiae* and *Streptococcus mitis* were isolated from the vitreous sample in two separate eyes. *Pseudomonas aeruginosa* was a cause of severe endophthalmitis in one eye that was initially treated by evisceration. It appears that in general, bacterial flora causing GDI related endophthalmitis in Saudi Arabia are similar to those reported in patients from the Western hemisphere.

Recommendations for the removal of the glaucoma shunt device at the time of treatment in an eye with endophthalmitis remain unclear. Gedde and Perkins recommended shunt removal at the time of treatment because of concerns the shunt might serve as a reservoir for the infectious organism.[4 26] In contrast, others have reported successful outcomes with intravitreal antibiotics without removing the shunt device.[23 36] In our series, there appeared to be no difference in final visual acuity relating to whether the implant was or was not removed at the time of treatment. However, it must be noted our sample size is too small to make any definite recommendations.

It is unclear whether pars plana vitrectomy with intravitreal antibiotics injection or vitreous tap with intravitreal antibiotics injection alone is the treatment of choice for GDI related endophthalmitis. Morad *et al*[17] reported three cases of endophthalmitis following AGV implant surgery. All cases were treated with implant removal, vitrectomy and intravitreal antibiotics; two eyes progressed to phthisis. Francis *et al*[25] reported poor outcome with vitreous tap and intravitreal antibiotics injection in a patient who developed endophthalmitis following a Baerveldt drainage implant despite rapid treatment. In our series it appeared that either initial approach to treatment (pars plana vitrectomy with intravitreal antibiotics or intravitreal antibiotic injection alone) did not have a significant impact on the final visual outcome. These findings may have been influenced by the relatively long interval between onset of symptoms and presentation.

In our series the visual outcome is poor. Of note is that most patients had poor visual acuity before the onset of infection because of either advanced glaucoma or corneal opacities.

In conclusion, endophthalmitis is a rare complication following AGV implant surgery and is usually delayed in onset. The rate of endophthalmitis following AGV implant surgery in the paediatric age group was five times higher than in adults. Conjunctival erosions over the AGV tube were present in most cases and seem to represent a major risk factor for endophthalmitis. Prompt surgical revision of such erosions is highly recommended.

Authors' affiliations
A A Al-Torbak, S Al-Shahwan, I Al-Jadaan, Department of Ophthalmology, King Khaled Eye Specialist Hospital, Riyadh, Saudi Arabia
A Al-Hommadi, Department of Research, King Khaled Eye Specialist Hospital, Riyadh, Saudi Arabia
D P Edward, Department of Ophthalmology, University of Illinois, Chicago, IL, USA

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