

Endophthalmitis Following Glaucoma Drainage Device Surgery

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Abstract

Background

To evaluate the risk of endophthalmitis in glaucoma patients undergoing glaucoma drainage device (GDD) surgery.

Methods

This retrospective cohort study identified glaucoma patients utilizing TriNetX's database who underwent GDD between 2004 and 2024 without a prior history of glaucoma surgery. Kaplan–Meier survival analysis estimated the cumulative incidence of endophthalmitis and a Cox proportional hazards model, adjusted for demographic and clinical covariates, was used to calculate adjusted hazard ratios (aHRs) and confidence intervals (CIs) comparing outcomes between patients who underwent tube shunt surgery versus trabeculectomy. A scleral buckle (SB) cohort was added as a second comparator to GDD to contextualize infection risk related to hardware without bleb formation.

Results

The GDD cohort included 12,849 patients (mean age 62.7 ± 19 years), compared with 9,006 trabeculectomy patients (67.9 ± 14.1) and 3,097 SB patients (45.1 ± 18.7). After GDD surgery, the cumulative incidence of endophthalmitis was 0.82% at 1, 1.57% at 3, and 1.87% at 5 years, compared with 0.47%, 0.78%, and 0.96% following trabeculectomy, and 0.19%, 0.23%, and 0.39% following SB. In Cox models, there was no significant difference in hazard between GDD and trabeculectomy at any timepoint. However, GDD was associated with higher risk than SB at 30 days (aHR 5.43, CI: 1.28–23.08, 1 year (aHR 3.36, 95% CI 1.88–5.99) and 5 years (aHR 3.71, 95% CI 2.40–5.73).

Conclusion

Endophthalmitis is an uncommon but persistent risk after GDD surgery. Although long-term risk was comparable between GDD and trabeculectomy, GDD implantation carried a higher risk than SB.

Introduction

Endophthalmitis represents one of the most significant complications following incisional glaucoma surgery such as trabeculectomy and glaucoma drainage device (GDD) implantation. Visual outcomes in these cases are generally unfavorable, with many patients sustaining profound and irreversible vision loss despite timely management. [1] Although the exact rate of endophthalmitis following GDD surgery remains uncertain, several studies reported range between 0.00197%–6.3%, with an even higher incidence observed in pediatric populations. [2–5]

Importantly, the risk of endophthalmitis persists long after GDD implantation, and numerous cases of late-onset endophthalmitis have been documented across all major device types, including the Ahmed,

Baerveldt, and Molteno implants. [6] One of the most significant predisposing factors is exposure of the tube or plate, which has been reported in up to 6% of cases. [3, 7] For this reason, prompt surgical repair of any GDD exposure is considered standard practice to reduce the risk of postoperative endophthalmitis. [6, 8]

Management of GDD-related endophthalmitis remains particularly challenging due to the absence of clear, evidence-based treatment guidelines. [5] While the Endophthalmitis Vitrectomy Study, conducted in the context of post-cataract surgery, demonstrated that patients with hand-motion visual acuity or better could often be managed effectively without vitrectomy, these findings may not be directly applicable to GDD-associated infections. [9, 10] In contrast, data from trabeculectomy bleb-associated endophthalmitis suggested improved visual outcomes with vitrectomy, regardless of presenting visual acuity. [11]

Longitudinal data directly comparing the cumulative incidence of endophthalmitis after GDD implantation versus trabeculectomy remain limited. The purpose of this study was to (1) assess the cumulative incidence of endophthalmitis following GDD implantation, (2) compare the hazard of endophthalmitis after GDD with that associated with bleb-forming surgery (trabeculectomy) (3) to further elucidate whether the observed risk of endophthalmitis was associated with bleb formation or the presence of an implanted drainage plate, a third comparator group was introduced. This group comprised patients without glaucoma who had a history of scleral buckle (SB) surgery for retinal detachment.

Methods

This retrospective cohort study utilized anonymized patient-level data from the TriNetX database (<https://trinetx.com/>), which aggregates health information from over 250 million de-identified individuals across more than 30 countries. For this investigation, data were last accessed in August 2025 from 72 healthcare organizations (HCOs) affiliated with the TriNetX “United States Collaborative” network. The study has been evaluated by the Institutional Review Board/Ethics Committee of the University of Arkansas and deemed not to require ethics approval. All research activities adhered to the ethical principles outlined in the Declaration of Helsinki.

The primary study group included patients with a coded diagnosis of glaucoma—defined by International Classification of Diseases, Tenth Revision (ICD-10) codes for glaucoma [H40–H42], congenital glaucoma [Q15.0], or absolute glaucoma [H44.5]—who had undergone primary GDD implantation, identified by the Current Procedural Terminology (CPT) codes 66179 and 66180. Patients were excluded if they had any prior history of glaucoma surgery as captured by the database, including iridotomy (CPT 66761), canaloplasty (CPT 66174), goniotomy (CPT 65820), trabeculectomy (CPT 66170, 66172, 66250), or cyclophotocoagulation (CPT 66710). Patients with a history of any vitreoretinal surgery was excluded as well.

The comparison group consisted of patients who underwent trabeculectomy without any prior glaucoma procedures, including GDD implantation. To further distinguish whether the risk of endophthalmitis was attributable to bleb formation versus the presence of an implanted plate, a third comparator group was created: patients without glaucoma who had a history of SB surgery for retinal detachment (ICD-10 H33), identified by CPT 67107. Combined SB and pars plana vitrectomy was excluded in this group using CPT codes 67036, 67108, and 67113.

Exclusion criteria for all groups included a history of endophthalmitis (ICD-10 H44.0, H44.1), chorioretinal inflammation (ICD-10 H30), or blebitis (ICD-10 H59.4). To ensure adequate ophthalmologic follow-up, eligible patients were required to have at least one clinical visit after their index procedure.

The study period spanned from August 1, 2004, to August 1, 2024. For each group, the index date was defined as the date of the surgical procedure, provided all inclusion and exclusion criteria were met. To prevent overlap between cohorts, patients who underwent more than one type of glaucoma surgery were excluded, ensuring that only the initial glaucoma procedure was analyzed. Adjustment for concomitant cataract surgery was performed in the analysis.

Clinical Endpoints

The primary clinical endpoints were the development of endophthalmitis (ICD-10 [H44.0 and H44.1] at 30 days, 1 year, and 5 years following GDD surgery. Patients who entered the cohort closer to 2024 and lacked sufficient follow-up to reach 5 years from their index date were excluded from the 5-year analysis but included in the 30-day and 1-year analyses.

Adjusted hazard ratios (aHRs) and 95% confidence intervals (CIs) for the association between tube shunt placement and each outcome were estimated using a Cox proportional hazards model, controlling for covariates of age, gender, race, ethnicity and relevant ocular and medical conditions. Controlled systemic conditions include diabetes mellitus (ICD-10 [E08-E11]), hypertensive diseases (ICD-10 [I10-I1A]), and systemic connective tissue disorders (ICD-10 [M30-M36]). Ocular conditions that were controlled include cataracts (ICD-10 [H25]), degenerative myopia (ICD-10 [H44.2]), pterygium of eye (ICD-10 [H11.0]), and retinopathy of prematurity (ICD-10 [H35.1]). Long term use of immunosuppressants (ICD-10 [Z79.6]) and steroids (ICD-10 [Z79.52]) as well as cataract surgery (CPT [1035657]) and intravitreal injection (CPT [67028]) were also controlled. The proportional hazards assumption was tested using the generalized Schoenfeld method.

Statistical Analysis

Time-to-event probabilities for endophthalmitis within the different cohorts were estimated using Kaplan-Meier survival analyses. Descriptive statistics were utilized to summarize baseline characteristics with means and standard deviations summarized as continuous variables and categorical variables summarized as proportions. Cumulative incidence of endophthalmitis was calculated as the proportion of patients in the study cohort who developed the outcome during the study

period. All statistical analyses were conducted using TriNetX's analytics platform with statistical significance being defined as a 2-sided p-value < 0.05

Results

Baseline Characteristics

A total of 12,849 individuals had undergone a GDD procedure during the study period with a mean age of 62.8 ± 18.8 years at the time of surgery. Of the tube shunt cohort, 51.9% were male, 74.1% were non-Hispanic or Latino, 54.2% were White, 24.2% were Black or African American, and 3.8% were Asian. In the trabeculectomy (9,006 patients) and SB (3,097 patients) comparison groups (Fig. 1), the mean age at the time of surgery was 67.9 ± 14.1 and 45.1 ± 18.7 , respectively. In the trabeculectomy group, 47.5% were male (58.1% in the SB group), 77.3% (76.2% in the SB group) were non-Hispanic or Latino, 54.2% (70.6% in the SB group) were White, 25.8% (10.7% in the SB group) were Black or African American, and 4.1% (4.1% in the SB group) were Asian (Table 1).

Cumulative Incidence of Endophthalmitis Following GDD Implantation

We found that the cumulative incidence of developing endophthalmitis following GDD procedures was 0.82% at 1 year, 1.57% at 3 years, and 1.87% at 5 years. The cumulative incidence following trabeculectomy was 0.47% at 1 year, 0.78% at 3 years, and 0.96% at 5 years. In the SB group the incidence of endophthalmitis was 0.19% at 1 year, 0.23% at 3 years, and 0.39% at 5 years (Table 2).

Glaucoma Drainage Devices versus Trabeculectomy and Scleral Buckle

A Cox proportional model was run to assess the hazards of endophthalmitis in the GDD group compared to trabeculectomy and SB groups, adjusting for baseline characteristics and confounding factors. Risk of endophthalmitis in the tube group did not differ statistically from trabeculectomy group at 30 days (aHR: 0.76, CI: 0.46–1.27, $p = 0.3$), 1 year (aHR: 0.97, CI: 0.073–1.27, $p = 0.81$), and 5 years (aHR: 1.17, CI: 0.96–1.42, $p = 0.12$). When compared to SB, the difference was statistically significant in the GDD group at 30 days (aHR 5.43, CI: 1.28–23.08, $p = 0.02$), 1 year (aHR: 3.29, CI: 1.8–6.02, $p < 0.001$) and 5 years (aHR: 4.71, CI: 2.78–7.99, $p < 0.001$) (Fig. 2).

Discussion

In this study, we quantified the cumulative incidence of endophthalmitis following GDD surgery. We found a cumulative incidence of 0.82% at 1 year, 1.57% at 3 years, and 1.87% at 5 years. This

aligns with prior reports, which described incidence rates ranging from 0.8% to 6.3%, with a pooled average of approximately 2%. [3] Retrospective data have similarly demonstrated delayed-onset infections related to device exposure, reinforcing the long-term vulnerability of GDD patients. [3, 6]

Comparisons with landmark clinical trials provide further perspective. The Tube Versus Trabeculectomy (TVT) trial reported a 5-year incidence of 1% following GDD implantation versus 5% after trabeculectomy. [12, 13] The Primary Tube Versus Trabeculectomy (PTVT) trial observed no cases of endophthalmitis in either group over a 5-year period. [14] The Ahmed Versus Baerveldt (AVB) study reported endophthalmitis rates of 1% for Ahmed glaucoma valve compared to 0% after Baerveldt glaucoma implant at 5 years, [15] while, the Ahmed Baerveldt Comparison (ABC) study reported rates of 0% in the Ahmed group versus 2.2% in the Baerveldt group. [16, 17] Although TVT found a higher risk of endophthalmitis in the trabeculectomy group, a recent study by Sabharwal et al [18] evaluated the Medicare dataset from 2016 to 2019 showing an endophthalmitis rate of 0.12% for all glaucoma surgeries, with the highest incidence observed in GDD procedures (2.0/1000 surgeries), followed by trabeculectomy (1.5/1000 surgeries). In multivariable analysis, GDD implantation carried a significantly higher risk compared with micro invasive glaucoma surgeries (adjusted odds ratio, 1.80; 95% CI, 1.24–2.62), while trabeculectomy and other procedures did not. [18] In our study, although there was a trend of higher cumulative incidence in the GDD group (0.82–1.87%) compared to trabeculectomy (0.47–0.96%), the difference was not statistically significant, after adjusting for demographic, systemic, and ocular covariates in the Cox hazards model.

The inclusion of a SB cohort provided valuable context for interpreting our findings. Although SB procedure is an invasive, it does not involve bleb formation or establish a fistulous between the intra- and extraocular environments. In our analysis, GDD was associated with approximately a 3-5-fold higher hazard of endophthalmitis compared with SB surgery, highlighting the specific risks conferred by bleb formation. This observation aligns with previous reports emphasizing that bleb-associated procedures carry an elevated infection risk due to potential bleb leakage or exposure. [19, 20] While endophthalmitis following SB surgery is uncommon, it can occur secondary to SB infection, particularly among high-risk population such as patients with atopic dermatitis. [21, 22] In our Cox model, the endophthalmitis in the SB surgery may be related to the cataract surgery or other interventions they had down the line; however, in our analysis we have adjusted for lens status or intravitreal injections.

Our study has several limitations including reliance on billing codes, which may lead to misclassification of diagnoses or procedures. We attempted to mitigate this by strict inclusion and exclusion criteria, but coding inaccuracies cannot be entirely excluded. Although our Cox model controlled for key demographic and clinical variables, including cataract surgery, systemic and ocular comorbidities, residual confounding is possible (e.g., variations in surgical technique, type of GDD, postoperative care, antibiotic prophylaxis, or severity of glaucoma). Furthermore, the TriNetX database does not allow for detailed evaluation of microbiologic profiles or visual outcomes following endophthalmitis, which limits our ability to comment on prognosis or optimal management strategies. In addition, because of the small number of eyes that developed endophthalmitis and TriNetX's confidentiality policy—where

outcomes involving fewer than 10 cases are suppressed—we were unable to assess specific post-endophthalmitis outcomes, such as the rates of evisceration or enucleation. Moreover, our data reflect patients within the US Collaborative and may not fully represent practice patterns or patient characteristics in other countries or health systems. Future prospective studies incorporating surgical details, microbiologic data, and visual outcomes are needed to guide evidence-based management of this serious and potentially sight-threatening complication.

In conclusion, endophthalmitis following GDD surgery is uncommon but carries a persistent long-term risk. Compared to trabeculectomy and scleral buckle, our analysis suggested GDD surgery is associated with higher risk of endophthalmitis compared to scleral buckle surgery. However, there was no difference between GDD and trabeculectomy groups. These findings highlight the need for continued vigilance in GDD implants, prompt recognition of potential exposures, and development of preventive strategies.

Declarations

Conflict of Interest: No conflicting relationship exists for any author.

Data Statement: Data is available through the TriNetX online database.

Author Contribution Statement:

AME was responsible for the study design, writing and reviewing the manuscript, interpreting the results, and supervision. AFA conducted the analysis, wrote the methods and results, and prepared visualization of data. HAS wrote the initial introduction and discussion. AMS conducted initial analysis and development of the methodology. RHE contributed to the formal analysis and writing the report. JM provided training in the use of the TriNetX platform. EB, NAY, and TCC provided feedback and direction on the report.

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associated with atopic dermatitis. *Ophthalmology*. 1999;106(1):142-7.

Tables

Table 1 is available in the supplementary file section. Table 2 is not available with this version.

Figures

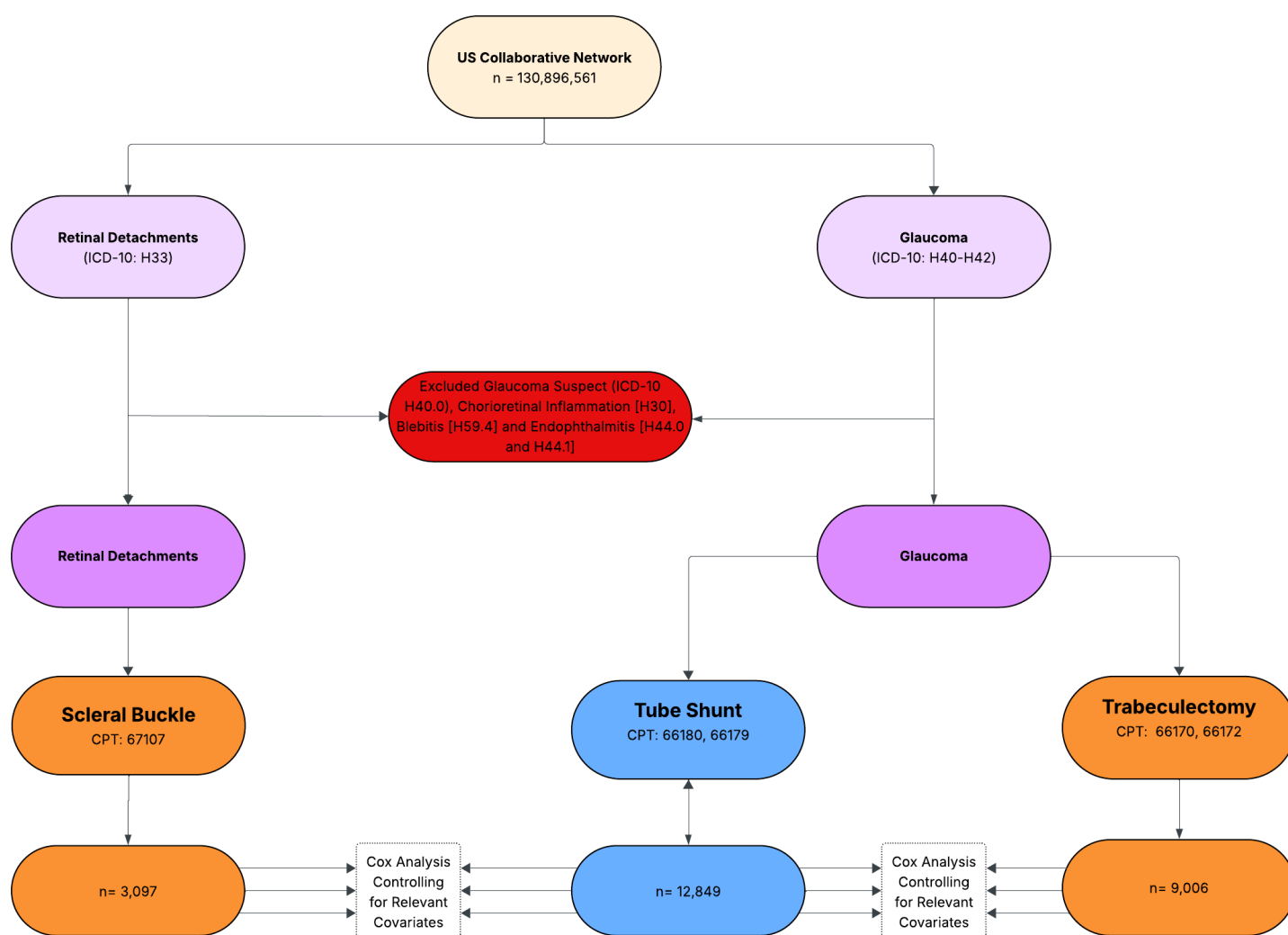


Figure 1

Flow chart depicting the selection of patients into tube shunt, trabeculectomy, and scleral buckle cohorts.

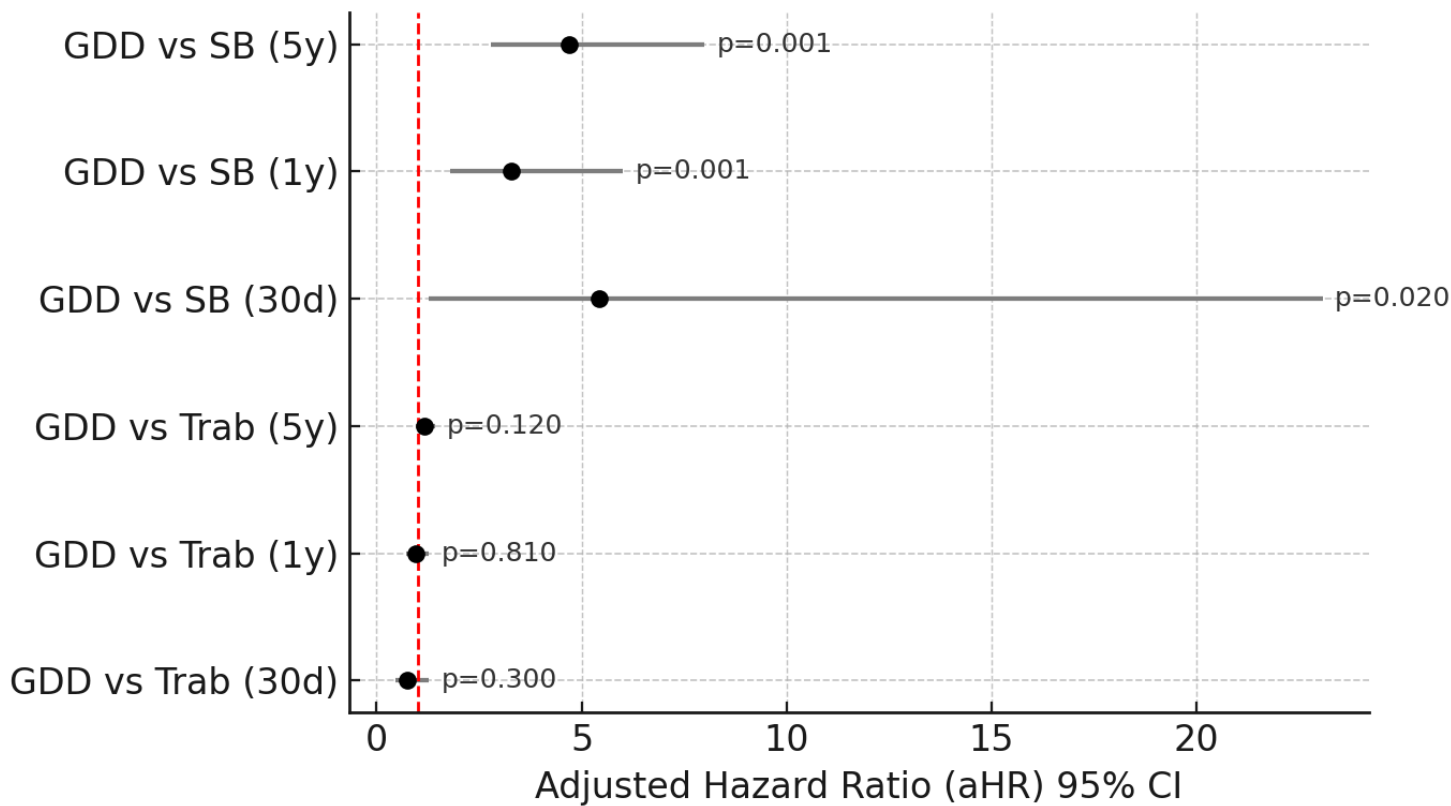


Figure 2

Forest plot depicting adjusted hazard ratios (aHRs) with 95% confidence intervals for the risk of endophthalmitis following tube shunt procedures compared with trabeculectomy and scleral buckle surgery.

Supplementary Files

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- [FinalBaselineCharacteristicsEndophthlamitis.docx](#)