

Temporal B-Scan Ultrasonography Findings and Their Relation to Visual Outcomes in Endophthalmitis

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Abstract

Purpose: To evaluate B-scan echographic features of endophthalmitis for their correlation with disease characteristics and long-term vision outcomes. **Methods:** Patients diagnosed with endophthalmitis at Massachusetts Eye and Ear between 2011 and 2021 were recruited (N = 209). Data included demographics, infection source, initial therapy, and findings from culture isolates, best-corrected visual acuity (BCVA), slitlamp, and B-scan ultrasonography. **Results:** More patients with positive microbial cultures, vs those with negative cultures, had dense vitreous debris on initial B-scan ($P = .008$). Patients whose initial slitlamp examination provided difficult/no view into the anterior chamber had more frequent findings of retinal detachment (RD) and T-sign ($P < .001$ and $P = .016$, respectively) and worse final mean BCVA ($P < .001$) vs patients with adequate views. Patients with dense vitreous opacities on initial B-scan had significantly worse initial mean BCVA vs patients with mild or moderate vitreous opacities ($P < .001$ and $P = .013$, respectively) and had significantly worse final mean BCVA vs patients with mild vitreous opacities ($P < .001$). Final mean BCVA was significantly worse in patients with choroidal detachment, RD, or T-sign than in patients without these features (each $P < .001$). Reductions in vitreous opacities and vitreous membranes were observed at 1 month postpresentation, whereas choroidal detachment was significantly more common at 1 week and RD more common at 1 month postpresentation. **Conclusions:** Positive cultures, specific microbial species, and B-scan findings (dense vitreous opacities, choroidal detachment, RD, and T-sign) are independent predictors of worse vision outcomes in patients with endophthalmitis.

Keywords

B-scan, endophthalmitis, retinal detachment, visual outcomes

Introduction

Endophthalmitis is characterized by inflammation of the internal structures of the eye resulting from intraocular infection. This infection is most frequently caused by intraocular surgeries, penetrating trauma to the eye, or endogenous infections, and can lead to irreversible vision loss if not treated timely and correctly.¹ However, diagnosing endophthalmitis can be difficult due to its diverse etiology and varied, nonspecific clinical presentation. Furthermore, the clinical manifestations of this condition can develop rapidly; thus, prompt and accurate diagnosis is crucial for guiding effective therapeutic interventions.

Clinical examination and microbial cultures play a pivotal role in diagnosing endophthalmitis, but funduscopy findings can be limited because opaque medium frequently prevents visualization of the posterior structures of the affected eye. In such cases, B-scan ultrasonography may be necessary for complete evaluation. Echography provides a quick and detailed view of ocular structures to facilitate accurate diagnosis of

endophthalmitis, monitor disease progression, and identify complications that may present as subtle structural changes. Echographic features associated with endophthalmitis have been described previously; these include vitreous opacities (ie, mobile, uniformly diffuse hyperechoic signals within the vitreous cavity), vitreous debris (ie, mobile, focal, irregularly shaped hyperechoic signals), vitreous membranes (ie, fixed linear densities), macular edema, subhyaloid and subretinal opacities, choroidal thickening, choroidal detachment, and retinal detachment (RD).^{2–4}

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Prior studies on echographic features of endophthalmitis have been limited in sample size,^{5–7} and, to our knowledge, there are no studies that have monitored the progression of B-scan ultrasonography findings over time. Thus, this study aimed to provide a current, large-scale investigation in patients with endophthalmitis to determine potential correlations of their initial and serial B-scan echographic features with visual acuity (VA) outcomes.

Methods

Study Cohort

This single-center retrospective case series was approved by the Mass General Brigham Institutional Review Board (protocol 2021P003477) and conformed to the tenets of the Declaration of Helsinki. The informed consent requirement was waived due to the retrospective nature of the study.

Eligible study subjects were patients ages 3–96 years who were evaluated at Massachusetts Eye and Ear Infirmary between 2011 and 2021 and diagnosed with endophthalmitis. Patients with incomplete medical records or those who underwent enucleation/evisceration of the affected eye were excluded. Thus, a total of 419 adult patients (429 eyes) with endophthalmitis were included. Among these patients, B-scan echographic images were obtained at the discretion of the treating physician from a total of 209 patients (212 eyes) as part of their diagnostic evaluation for endophthalmitis.

A standardized protocol was followed for B-scan ultrasonography. The examination was performed by 3 operators using institutional ultrasound devices equipped with 10 MHz and 20 MHz probes. For sanitary reasons, all probes were placed on the eyelids. Each patient received a full B-scan examination, which included axial, transverse, and longitudinal scans at various clock hours. Probe positioning was performed nasally and superiorly, with imaging conducted along multiple axes, including horizontal axial, vertical disc axial, vertical macula axial, nasal transverse, temporal transverse, inferior transverse, superior transverse, and longitudinal views.

A total of 8 B-scan images per eye were acquired for interpretation. Specific scans were utilized depending on the feature being assessed. The images were acoustically analyzed and interpreted by the operators, with clinical correlations determined at the discretion of the treating physicians. To ensure comprehensive assessment, both eyes were scanned in all cases. The initial B-scan ultrasound was performed within 1 day of initial presentation in a total of 135 patients (135 eyes). These initial scans were used as the baseline examination to compare echographic features with other qualitative data and VA outcomes. Thereafter, a total of 55 patients (55 eyes) received serial B-scan examinations over the follow-up period, including a baseline examination within 3 days of presentation, an examination within 1 week of presentation (days 7–11), and an examination within 2–4 weeks of presentation (days 14–33). These data were used to evaluate potential correlations between changes in echographic findings over time and VA outcomes.

Data collected for this study included patient demographics, infection source (endogenous or exogenous), microbial culture isolates (obtained via anterior chamber aqueous paracentesis, vitreous tap, or corneal culture), best corrected visual acuity (BCVA) (in logMAR) at initial presentation, slitlamp findings on initial examination, B-scan-specific findings on initial examination and follow-up visits, and initial therapy for endophthalmitis. B-scan findings included the presence of vitreous membranes, identified as continuous, sheet-like proliferations with a consistent ultrasonographic pattern, vitreous opacities, appearing as discrete, scattered echoes within the vitreous cavity, and vitreous debris. The severity of vitreous opacities was graded as mild, moderate, or severe based on the extent and density of echoes observed on imaging. When applying this grading scheme, in which standardized protocols were used, the interpreting ultrasonographer assigned severity grades for vitreous opacities at their discretion. Other B-scan echographic features included RD, which appear as thick folded membranes with a limited movement and have 100% amplitude when compared with choroid sclera, and posterior vitreous detachments, which appear as thin wavy membranes that move freely with ocular movements and usually have an amplitude that is significantly lower than 100% in comparison. Other documented features included choroidal thickening, choroidal detachment, visualized as convex indentations into the vitreous cavity with limited mobility, and T-signs, visualized as thickened posterior sclera with fluid in the Tenon's capsule adjacent to the optic nerve. The B-scan examinations were performed and interpreted by 1 of 3 echography technicians, who followed a nonstandardized protocol. The findings were then co-signed in the clinical notes by the treating physicians, and confirmed by one of the authors (C.C.), who performed a retrospective review of all images during data collection.

The primary outcome investigated was the final BCVA, defined as the patient's VA at 12 months or the patient's last recorded BCVA within 12 months. The standard logMAR scale was used for statistical analysis of BCVA, with counting fingers (CF) VA assigned a logMAR of 2.3, hand motions (HM) VA a logMAR of 2.6, light perception (LP) VA a logMAR of 3.0, and no light perception (NLP) VA a logMAR of 4.0.

Statistical Analysis

Statistical analysis was performed using SPSS Statistics version 29.0 (IBM Analytics). In descriptive analyses of continuous variables, data are presented as the mean ($\pm$ SD) and median, and data for categorical variables are presented as frequencies with percentages.

Two-sided Student *t* test was used to compare continuous variables with equal population variances, and Welch's *t* test was used to compare groups with unequal population variances according to Levene's test. The χ^2 test (Fisher exact test) was used to compare categorical variables between groups. A binary logistic regression analysis and a linear regression analysis were used to assess correlations between qualitative echographic findings and VA outcomes. The Bonferroni correction was

Table 1. Characteristics of Patients with Endophthalmitis Who Received B-scan Ultrasonography at Initial Presentation (n = 135), and Source of Infection.

Parameter	Value
Characteristic	
Age, y, mean $\pm$ SD	67.61 $\pm$ 19.68
Sex, male, n (%)	75 (55.5)
Source of Infection, n (%)	
Exogenous	95 (70.4)
Cataract surgery	33 (34.7)
Anti-vascular endothelial growth factor injections	19 (20.0)
Glaucoma filtration surgery	19 (20.0)
Other surgeries	14 (14.7)
Penetrating keratoplasty	6 (6.3)
Keratoprosthesis	4 (4.2)
Endogenous	37 (27.4)
Unknown	3 (2.2)

applied to multiple-comparison tests. Statistical significance was set at $P < .05$.

Results

Baseline Characteristics

The study assessed a total of 209 patients (212 eyes) diagnosed with endophthalmitis who had received formal B-scans as part of their clinical evaluation. Of these 209 patients, 53.8% were male, and the mean age at diagnosis was 67.07 ± 19.49 years. The mean BCVA at diagnosis was 2.38 ± 0.78 logMAR (CF to HM), and median BCVA was 2.6 logMAR (HM). On average, patients received their first B-scan by 2.12 ± 4.37 days (median, 1 day) after endophthalmitis diagnosis, and received a total of 3.08 ± 2.16 B-scans over the course of a year of follow-up visits for endophthalmitis care. Within 1 day of presentation, 135 patients (135 eyes) (64.6% of the cohort; mean age at diagnosis 67.61 ± 19.68 years, 55.5% male) had received a B-scan as part of their initial evaluation.

Source of Infection and Culture Findings

Of the 135 patients who received an initial B-scan, 37 patients (27.4%) were noted to have endogenous sources of infection, whereas 95 patients (70.4%) had exogenous causes of infection and 3 patients (2.2%) had unknown sources (Table 1). Exogenous causes included cataract surgery (n = 33, 34.7%), anti-vascular endothelial growth factor injections (n = 19, 20.0%), glaucoma filtration surgery (n = 19, 20.0%), penetrating keratoplasty (n = 6, 6.3%), keratoprosthesis (n = 4, 4.2%), and other surgeries (n = 14, 14.8%). There were no statistically significant differences in initial BCVA, final BCVA, and echographic features on initial B-scan evaluation between patients with endogenous sources and those with exogenous sources of endophthalmitis ($P > .05$).

Similar comparisons were made between patients with culture-positive endophthalmitis (n = 83, 61.5%) and those with

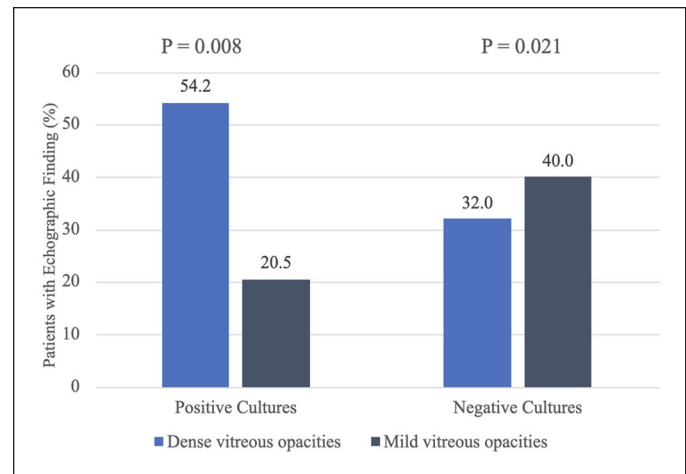


Figure 1. B-scan echographic findings of dense vitreous opacities or mild vitreous opacities in patients with endophthalmitis grouped according to culture findings (culture-positive vs culture-negative for any microbial species). Values are percentages of patients. P values for group comparisons were determined by Fisher exact test.

culture-negative endophthalmitis (n = 50, 37.0%); 2 patients (1.5%) did not have culture data. Significantly more patients with positive microbial cultures than those with negative cultures had dense vitreous debris findings on initial B-scan (n = 45, 54.2% vs n = 16, 32.0%) ($P = .008$) (Figure 1). There were no statistically significant differences in the initial mean BCVA or final mean BCVA between patients with culture-positive endophthalmitis and those with culture-negative endophthalmitis ($P > .05$).

The isolated microorganisms identified in cultures from patients with endophthalmitis are listed in Table 2. Given the small numbers of specific isolates, the organisms were divided into 6 categories: coagulase-negative staphylococcal species (n = 24, 28.9%), streptococcal species (n = 20, 24.1%), other gram-negative species (n = 13, 15.7%), *Staphylococcus aureus* (n = 8, 9.7%), fungi (n = 7, 8.4%), other gram-positive species (n = 6, 7.2%), and mixed organisms (n = 4, 4.8%). One patient (1.2%) had a positive culture but the isolated organism was unknown.

Final BCVAs were compared between endophthalmitis patients grouped according to the different infectious organisms present. The final mean BCVA was significantly worse in patients with other gram-positive species (final mean BCVA, 2.96 logMAR [HM to LP]; $P = .005$) and in patients with streptococcal species (final mean BCVA, 2.55 logMAR [CF to HM]; $P = .002$) compared with patients who had *Staphylococcus aureus* isolates (final mean BCVA, 1.19 logMAR; VA 20/300–20/320); the 95% CI of the difference in final BCVA was –2.544 to –0.276 in those with other gram-positive species and –2.523 to –0.121 in those with streptococcal species relative to the *Staphylococcus aureus* group (Table 3). Differences in the initial BCVAs and B-scan ultrasonography findings were not statistically significant between the groups according to presence of each isolated organism ($P > .05$).

Table 2. Isolated Microorganisms Identified in Culture Isolates From Patients With Endophthalmitis (n = 83 assessed), by Microbial Category.

Staphylococcal Species (n = 32, 38.6%)	Streptococcal Species (n = 20, 24.1%)	Gram-negative Species (n = 13, 15.7%)	Gram-positive Species (n = 6, 7.2%)	Fungal Species (n = 7, 8.4%)	Other (n = 5, 6%)
<i>Staphylococcus epidermidis</i> (n = 15)	<i>Streptococcus mitis</i> (n = 12)	<i>Haemophilus influenzae</i> (n = 3)	<i>Enterococcus faecalis</i> (n = 2)	<i>Candida albicans</i> (n = 3)	Multiple mixed organisms (n = 4)
<i>Staphylococcus aureus</i> (n = 8)	<i>Streptococcus pneumoniae</i> (n = 2)	<i>Serratia marcescens</i> (n = 3)	<i>Bacillus</i> (n = 2)	Nonspecific fungus (n = 2)	Unknown (n = 1)
Other coagulase-negative <i>Staphylococci</i> (n = 7)	<i>Viridans streptococcus</i> (n = 2)	<i>Klebsiella pneumoniae</i> (n = 2)	<i>Gemella haemolysans</i> (n = 1)	<i>Candida dubliniensis</i> (n = 1)	
<i>Staphylococcus capitis</i> (n = 2)	Group G β -hemolytic streptococci (n = 1)	<i>Pseudomonas fluorescens/putida</i> (n = 1)	<i>Propionibacterium acnes</i> (n = 1)	<i>Scedosporium apiospermum</i> (n = 1)	
	<i>Streptococcus salivarius</i> (n = 1)	<i>Citrobacter koseri</i> (n = 1)			
	<i>Streptococcus sanguinis</i> (n = 1)	<i>Pseudomonas aeruginosa</i> (n = 1)			
	Nonspecific <i>Streptococcus</i> species (n = 1)	<i>Moraxella catarrhalis</i> (n = 1)			
		<i>Achromobacter xylosoxidans</i> (n = 1)			

Table 3. Final Mean Best-Corrected Visual Acuity Outcomes by Isolated Infectious Microorganism.

Microorganism	Final Mean BCVA (logMAR)	BCVA Measure
Other gram-positive species (n = 6)	2.96	HM to LP
Streptococcal species (n = 20)	2.55	CF to HM
<i>Staphylococcus aureus</i> (n = 8)	1.19 ^a	20/300–20/320

Abbreviations: BCVA, best corrected visual acuity; CF, counting fingers; HM, hand motions; LP, light perception.

^aPatients with isolated *Staphylococcus aureus* had significantly better final mean BCVA compared with patients with isolated other gram-positive species ($P = .005$) and streptococcal species ($P = .002$).

Table 4. Final Best-Corrected Visual Acuity Outcomes by Slitlamp Examination Findings.

Slitlamp Finding	Final Mean BCVA (logMAR)	BCVA Measure	P
Anterior Chamber View			
Difficult/No View (n = 16)	2.72	HM to LP	<.001
Adequate View, 0–4+ Cells (n = 109)	1.53	20/650–20/800	
Hypopyon			
Present (n = 77)	1.89	20/1300–20/1600	.042
Absent (n = 44)	1.40	20/500	

Abbreviations: BCVA, best corrected visual acuity; HM, hand motions; LP, light perception.

Slitlamp Examination and B-scan Ultrasonography Findings

The final mean BCVA outcomes were compared in relation to initial slitlamp examination findings. A total of 125 (92.6%) of the 135 patients with initial B-scans also had available slitlamp examination findings, and 121 of these patients (89.6%) had reports that included comments on the presence or absence of a hypopyon. Patients whose initial slitlamp examination had a difficult/no view of the anterior chamber (n = 16, 12.8%)—attributable to factors such as corneal edema or haze, corneal ulcer, and hypopyon—had a significantly worse final mean BCVA compared with patients whose slitlamp examination provided an adequate view into the anterior chamber, with 0 to 4+ cells (n = 109, 87.2%); the final mean BCVA was 2.72 logMAR (HM to LP) in the difficult/no view group compared with a final mean BCVA of 1.53 logMAR (VA 20/650–20/800) in the adequate view group ($P < .001$), and the 95% CI of the difference was -1.809 to -0.536 . Patients with a hypopyon on initial slitlamp examination (n = 77, 63.6%) had a final mean BCVA that was slightly significantly worse than that in patients without a hypopyon (n = 44, 36.4%) (final mean BCVA, 1.89 logMAR [VA 20/1300–20/1600] vs 1.40 logMAR [VA 20/500], $P = .042$; 95% CI of difference, 0.021 to 0.959) (Table 4).

The B-scan findings on initial examination were compared in relation to initial slitlamp examination findings. Patients with a difficult/no view on initial slitlamp examination had a significantly higher frequency of RD on the initial B-scan compared with patients whose slitlamp examination had an adequate view into the anterior chamber (31.2% vs 2.7%, $P < .001$). In addition, patients with no view into the anterior chamber on initial slitlamp examination also had a significantly higher frequency of T-sign findings on the initial B-scan compared with patients with an adequate view on slitlamp examination (25.0% vs 4.6%, $P = .016$).

There were no significant differences in the final mean BCVA between patients with and patients without keratic precipitates, posterior capsular plaque, or vitritis findings on initial slitlamp examination (all $P > .05$).

Initial B-scan Findings and VA Outcomes

Of the patients who received a B-scan at initial evaluation (n = 135), the initial mean BCVA was 2.44 ± 0.75 logMAR (CF to HM) and the median BCVA was 2.6 logMAR (HM). In these patients, the final mean BCVA showed improvement but was still poor, with a final mean BCVA of 1.49 ± 1.31 logMAR (VA 20/500 to 20/640) and median VA of 2.3 (CF).

Vitreous opacities were observed in 124 patients (91.9%) on the initial B-scan evaluation (Figure 2). Patients with dense vitreous opacities (n = 61, 49.2%) on initial B-scan had a significantly worse initial mean BCVA (2.74 logMAR [HM to LP]) compared with patients with moderate vitreous opacities (n = 25, 20.2%) (initial mean BCVA, 2.22 logMAR [VA 2/200–1/200], $P = .013$; 95% CI of difference, 0.822 to 0.946), and also had a significantly worse initial mean BCVA compared with patients with mild vitreous opacities (n = 38, 30.6%) (initial mean BCVA, 2.07 logMAR [VA 2/200–2/250], $P < .001$; 95% CI of difference, 0.283 to 1.048). At the end of follow-up, patients with dense Vitreous opacities on initial B-scan also had a significantly worse final mean BCVA (2.22 logMAR [VA 2/200–1/200]) compared with patients with mild vitreous opacities on initial B-scan (final mean BCVA, 1.14 logMAR [VA 20/200–20/300], $P < .001$; 95% CI of difference, 0.417 to 1.745).

Patients with choroidal detachment on initial B-scan (n = 32, 23.7%) had a significantly worse final mean BCVA compared with patients who did not have this feature (n = 103, 76.3%) (final mean BCVA, 2.26 logMAR [VA 2/200–1/200] vs 1.59 logMAR [VA 20/650–20/800] [$P = .001$]; 95% CI of difference, -1.178 to -0.164). Similarly, patients with RD on

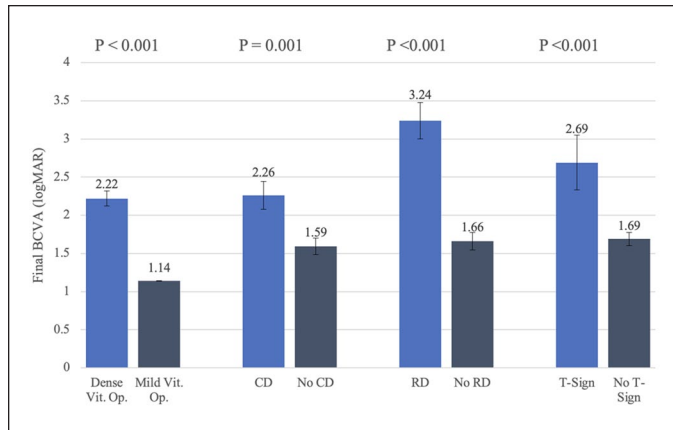


Figure 2. Final best-corrected visual acuity (BCVA) at follow-up according to B-scan echographic features on initial presentation in patients with endophthalmitis, including those with dense vs mild vitreous opacities (Vit. Op.), those with or without choroidal detachment (CD), those with or without retinal detachment (RD), and those with or without T-signs. Values are the mean ($\pm$ SD) final BCVA (in logMAR). P values for group comparisons were determined by Fisher exact test.

initial B-scan ($n = 8$, 5.9%) had a significantly lower final mean BCVA compared with patients without RD ($n = 127$, 94.1%) (final mean BCVA, 3.24 logMAR [LP to NLP] vs 1.66 logMAR [VA 20/800–20/1000] [$P < .001$]; 95% CI of difference, -2.164 to -0.992).

Patients with T-sign present on the initial B-scan ($n = 9$, 6.7%) had a significantly worse final mean BCVA compared with those without T-sign present ($n = 126$, 93.3%) (final mean BCVA, 2.69 logMAR [HM to LP] vs 1.69 logMAR [VA 20/800–20/1000], $P < .001$; 95% CI of difference, -1.878 to -0.122).

When echographic findings were assessed by linear regression analysis to determine whether there was a correlation with VA outcomes, we found that dense vitreous opacities on initial B-scan examination was associated with a significantly worse predicted final BCVA (logMAR) ($B = 0.527$ [95% CI, 0.032 to 1.022]; $P = .028$). Similarly, evidence of RD on initial B-scan was associated with a significantly worse predicted final BCVA (logMAR) ($B = 1.304$ [95% CI, 0.438 to 2.171]; $P = .012$).

To further investigate this relationship, patients were grouped according to whether their final BCVA had remained stable/improved ($n = 103$, 76.3%) or had worsened ($n = 32$, 23.7%) over the follow-up compared with their initial BCVA. The correlation between echographic findings and VA outcomes was then assessed through binary logistic regression analysis. Patients with RD on initial B-scan were less likely to exhibit stable/improved vision according to their final BCVA (odds ratio = 0.047, 95% CI, 0.005 to 0.408; $P = .018$). Findings of vitreous opacities and choroidal detachment on initial B-scan showed no significant correlation with the final mean BCVA ($P > .05$).

Progression of B-scan Findings

A total of 55 patients (55 eyes) received serial B-scans at the follow-up visits for their endophthalmitis care: a baseline scan

Table 5. Progression of Serial B-Scan Echographic Features Over Follow-up in Patients With Endophthalmitis

Timepoint, Echographic Feature	No. (%)
Days 0–3	
Mild vitreous opacities	16 (29.1) ^a
Moderate vitreous opacities	4 (7.3)
Dense vitreous opacities	31 (56.4) ^b
Vitreous membrane (+ posterior attachment)	6 (10.9)
Vitreous membrane (loose)	22 (40.0) ^{c,d}
Choroidal detachment	18 (32.7)
Retinal choroidal thickening	14 (24.4)
Retinal detachment	2 (3.6)
Posterior vitreous detachment	2 (3.6)
T-sign	5 (9.1)
Other	8 (14.5)
Days 7–11	
Mild vitreous opacities	7 (12.4)
Moderate vitreous opacities	13 (23.6) ^e
Dense vitreous opacities	25 (45.4)
Vitreous membrane (+ posterior attachment)	11 (20.0)
Vitreous membrane (loose)	12 (21.8)
Choroidal detachment	28 (50.9) ^f
Retinal choroidal thickening	16 (29.1)
Retinal detachment	6 (10.9)
Posterior vitreous detachment	2 (3.6)
T-sign	6 (10.9)
Other	7 (12.7)
Days 14–33	
Mild vitreous opacities	12 (21.8)
Moderate vitreous opacities	10 (18.2)
Dense vitreous opacities	18 (32.7)
Vitreous membrane (+ posterior attachment)	9 (16.4)
Vitreous membrane (loose)	12 (21.8)
Choroidal detachment	16 (29.1)
Retinal choroidal thickening	14 (24.4)
Retinal detachment	15 (27.3) ^{g,h}
Posterior vitreous detachment	4 (7.3)
T-sign	3 (5.4)
Other	6 (10.9)

^a $P = .035$, initial vs >1 week.

^b $P = .013$, initial vs >1 month.

^c $P = .039$, initial vs >1 week.

^d $P = .039$, initial vs >1 month.

^e $P = .033$, initial vs >1 week.

^f $P = .020$, initial vs >1 month.

^g $P = .029$, initial vs >1 month.

^h $P < 0.001$, initial vs >1 week.

at 0–3 days (average day of scan, 0.873 days; median, 1 day), a scan at 1 week (average day of scan, 7.309 days; median, 7 days), and a scan at 2–4 weeks (average day of scan, 20.872 days; median, 20 days). The frequencies of each B-scan finding were compared at each time point (Table 5).

Initial vs 1-week scans. Mild vitreous opacities and loose vitreous membranes were slightly more common on initial B-scans

(mild vitreous opacities, $n = 16$, 29.1%; loose vitreous membranes, $n = 22$, 40.0%) than on 1-week scans (mild vitreous opacities, $n = 7$, 12.43% [$P = .035$]; loose vitreous membranes, $n = 12$, 21.8%) ($P = .039$). Moderate vitreous opacities findings were significantly more common on 1-week scans ($n = 13$, 23.6%) than on initial scans ($n = 4$, 7.3%) ($P = .033$).

1-week vs 1-month scans. Choroidal detachment findings were significantly more common on 1-week B-scans ($n = 28$, 50.9%) than on 1-month scans ($n = 16$, 29.1%) ($P = .020$). Conversely, RD findings were significantly more common on 1-month B-scans ($n = 15$, 27.3%) than on 1-week B-scans ($n = 6$, 10.9%) ($P = .029$).

Initial vs 1-month scans. Dense vitreous opacities and loose vitreous membranes were more common on initial B-scans (dense vitreous opacities, $n = 31$, 56.4%; loose vitreous membranes, $n = 22$, 40.0%) than on 1-month scans (dense vitreous opacities, $n = 18$, 32.7%) [$P = .013$]; loose vitreous membranes, $n = 12$, 21.8% [$P = .039$]). However, there was a significantly higher frequency of RD on 1-month B-scans ($n = 15$, 27.3%) than on initial scans ($n = 2$, 3.6%) ($P < .001$).

BCVA in Relation to Serial B-scan Findings and Treatment

The final mean BCVA was compared between patients who developed certain echographic findings over the 1-month time period and patients who did not develop these B-scan findings (Figure 3). All patients who developed choroidal detachment in the 1-month time period ($n = 31$, 56.4%) had a significantly worse final BCVA (final mean BCVA, 2.56 logMAR [CF to HM]) compared with patients who did not develop choroidal detachment ($n = 24$, 43.6%; final mean BCVA, 1.67 logMAR [VA 20/800–20/1000]) ($P = .008$). Similarly, all patients who developed RD in the 1-month time period ($n = 16$, 29.1%) had a significantly worse final BCVA (final mean BCVA, 2.84 logMAR [HM to LP]) compared with patients who did not develop RD ($n = 39$, 70.9%; final mean BCVA, 1.81 logMAR [VA 20/1250–20/1300]) ($P = .002$).

Among those who had serial B-scans over 1 month, 31 patients (56.3%) received a vitrectomy for endophthalmitis treatment. The remaining patients, who did not undergo vitrectomy, were treated with intraocular antibiotics alone ($n = 8$, 14.5%), intraocular and topical antibiotics ($n = 7$, 12.7%), or intraocular, topical, and systemic antibiotic therapy ($n = 7$, 12.7%). There was no significant difference in echographic findings between those who received a vitrectomy and those who did not ($P > .05$). There was also no significant difference in the final mean BCVA among patients subcategorized by initial BCVA and compared by treatment ($P > .05$). There were significantly more patients who developed RD after vitrectomy compared with those who did not undergo vitrectomy ($n = 12$, 38.7% vs $n = 3$, 12.5%) ($P = .024$) (Table 6). There was no significant association between time to vitrectomy and final BCVA ($P > .05$).

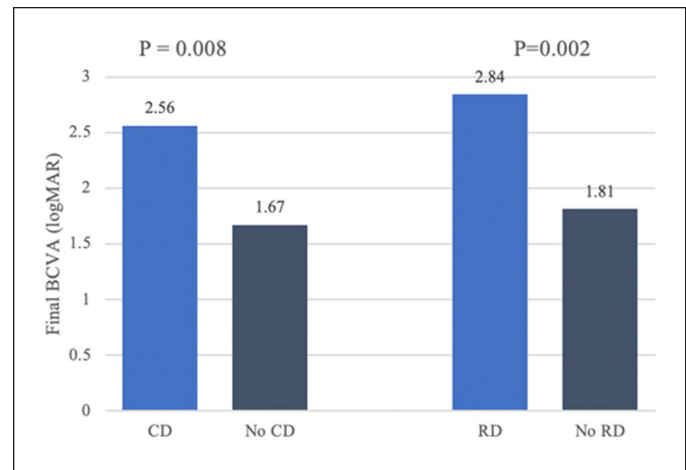


Figure 3. Final best corrected visual acuity (BCVA) at follow-up according to serial B-scan echographic findings in patients with endophthalmitis, including those with or without choroidal detachment (CD) and those with or without retinal detachment (RD). Values are the mean ($\pm$ SD) final BCVA (in logMAR). P values for group comparisons were determined by Fisher exact test.

Conclusions

Presently, there is limited scientific literature examining the relationship between B-scan ultrasonography findings in patients diagnosed with endophthalmitis and vision outcomes. This study provides a large, current investigation of initial and serial echographic features of endophthalmitis and their relationship to VA outcomes. Overall, the major findings of this study include: 1) patients with dense vitreous opacities on initial B-scan examination and those who developed choroidal detachment or RD echographic findings from the initial visit to the 1-month follow-up visit had a significantly worse final mean BCVA; 2) patients with positive cultures had significantly more dense vitreous debris findings on initial B-scan than patients with negative cultures, and patients with isolated other gram-positive species or streptococcal species had significantly worse vision outcomes than those with isolated *Staphylococcus aureus*; 3) patients with difficult/no view or a hypopyon on initial slitlamp examination had a significantly worse final BCVA compared with patients who had an adequate slitlamp view into the anterior chamber and no hypopyon on initial examination, and RD and T-sign findings on B-scan ultrasonography were significantly more frequent in patients with no slitlamp view into the anterior chamber.

Our study is unique in that it is the first study, to our knowledge, that analyzes serial changes in echographic findings over time and assesses their correlation to VA outcomes. The development of RD or choroidal detachment from the initial visit to the 1-month follow-up after diagnosis was associated with significantly worse VA outcomes. These are valuable data supporting the benefit of utilizing ultrasound to continually monitor a patient's disease over time, particularly since choroidal detachment and RD were not uncommon and were most frequently

Table 6. Initial and Final BCVA Outcomes and B-Scan Echographic Findings After Treatment in Patients With Endophthalmitis Who Did Or Did Not Receive Vitrectomy.

Treatment	Initial Mean BCVA (logMAR)	Final Mean BCVA (logMAR)	RD after treatment (n [%])
Vitrectomy (n = 31)	2.53	2.29	12 (38.7) ^a
No Vitrectomy (n = 24)	2.63	2.09	3 (12.5)

Abbreviations: BCVA, best corrected visual acuity; RD = retinal detachment.

^aP = .024 vs no vitrectomy.

found on 1-week and 1-month scans, respectively, in this cohort. Specifically, the incidence of RD with endophthalmitis in this group who received serial B-scans was slightly higher (29.1%) than that reported in previous studies, in which the incidence of RD ranged from 8.5% to 25% in patients with endophthalmitis.^{8–13} This may be because patients who presented with more severe endophthalmitis were more likely to receive serial B-scan examinations. Nevertheless, the delayed presentation of this complication has also been reported in other studies. In a study by Wang et al¹¹ involving 108 patients with endophthalmitis, the authors found that the average time to develop RD was 27 days. Similarly, Zheng et al¹⁴ evaluated patients with endophthalmitis (116 eyes) who received treatment with 23G pars plana vitrectomy, and found that the average time to develop RD was 25 days after endophthalmitis diagnosis. If patients are not monitored regularly, especially those with complex disease, serious complications may be missed. Moreover, if left without treatment for an extended time period, complications such as RD can cause significant, irreversible decline in VA.^{15–17}

Relevant to our findings of an association between B-scan echographic findings and poor vision outcomes, echography is often utilized in endophthalmitis cases when opaque medium prevents visualization of the posterior segment. The current study identified dense vitreous debris, choroidal detachment, and RD as independent findings on initial B-scan examination that were associated with poorer VA outcomes. Echographic features such as dense vitreous opacities, vitreous membranes, choroidal thickening, posterior vitreous detachment, and choroidal detachment or RD have all been associated with endophthalmitis in prior studies.^{2,3,18–20} These findings are not specific to endophthalmitis, but can help in the diagnosis of this disease, in conjunction with clinical symptoms. Only a few studies have investigated the relationship between echographic features and vision outcomes. Dacey et al studied the eyes of patients with endophthalmitis and reported that poor final VA outcomes (VA <1/200 [LP]) were associated with certain findings on initial B-scan examination, including dense vitreous opacities, vitreous membranes, choroidal detachment, and the presence and extent of RD. A decrease in vision during follow-up was associated with the combined presence of vitreous opacities and subhyaloid opacities, choroidal detachment, and RD on initial examination.⁷ Rachitskaya et al⁶ found that, of the 148 endophthalmitis patients assessed, the presence of dense vitreous opacities, vitreous membranes, RD, and choroidal detachment on initial B-scan examination was correlated with poorer VA outcomes. The results of these 2 studies are consistent with our current findings. However, in another study, by Maresová

et al,¹⁹ in which the sample size was limited (7 eyes examined in patients with endophthalmitis), there was no specific echographic feature that was found to be associated with poor VA outcomes. All of these studies found a correlation of initial B-scan findings to VA outcomes. The worse outcomes, characterized by dense opacities, may lend support for the decision to use early vitrectomy in these cases.

Regarding the types of infectious organisms and isolated microorganisms present in patients with endophthalmitis, the current study found that patients with cultures positive for *Staphylococcus aureus* had significantly better vision outcomes as compared with patients with other gram-positive species and streptococcal species, but echographic findings did not significantly differ among the patients with the different microorganisms. Previous studies investigating the relationship between causative microorganisms, echographic findings, and visual prognosis in patients with endophthalmitis have not been conclusive. Similar to our findings, Rachitskaya et al⁶ found that endophthalmitis patients with coagulase-negative staphylococci had the best vision outcomes as compared with patients who were culture-negative or those who had cultures positive for other microbial species, and the echographic findings did not significantly differ between the different microorganism groups. However, unlike our current study, some previous research has found a relationship between isolated microorganisms and initial echographic findings. Dacey et al found that advanced streptococcal endophthalmitis was correlated with severe vitreous opacities, vitreous membranes, and complete posterior vitreous detachment on initial examination. Additionally, choroidal detachment was more commonly found in gram-negative endophthalmitis. The authors concluded, however, that echographic features, such as choroidal detachment, were more strongly associated with the final vision outcomes than with the causative organism.⁷ Patil et al⁵ examined 28 eyes of patients with endophthalmitis associated with cataract surgery, and found that dense vitreous opacities on initial B-scan examination was correlated significantly with the presence of *Staphylococcus aureus* and *Pseudomonas aeruginosa* endophthalmitis. Although those data provide insights into the relationship between infective microorganisms and vision outcomes in endophthalmitis, the results remain nonspecific with regard to identifying correlations between microorganisms and echographic features, in contrast to the current study findings.

The slit-lamp examination also plays an important role in the diagnosis of endophthalmitis. We demonstrated that patients with difficult/no view or a hypopyon on initial slitlamp examination had a significantly worse final BCVA compared with patients whose slitlamp examination provided an adequate

view into the anterior chamber and patients with no hypopyon on initial examination. Previous studies have demonstrated that patients with endophthalmitis can present with varying signs and symptoms, including ocular redness, hypopyon, and intraocular inflammation.^{21–25} These aforementioned studies focused primarily on slitlamp findings in diagnosing endophthalmitis, but a few studies have also investigated the relationship between slitlamp findings and vision outcomes. Kurniawan et al²⁶ examined patients with streptococcal endophthalmitis and found that no view of the fundus on initial slitlamp examination was significantly associated with poor VA outcomes (BCVA <6/60). Comparably, Senthamizh et al²⁷ found that an inability to visualize the optic disc on slitlamp examination was associated with a poor VA outcome (BCVA <6/60); that study also revealed that the absence of a hypopyon was independently associated with good VA outcomes (BCVA >6/12). However, unlike the current study, none of those previous studies identified a correlation of these slitlamp findings with echographic features. Specifically, our findings revealed that patients with no view into the anterior chamber on slitlamp examination had significantly more frequent findings of RD and T-sign on initial echographic examination. These results emphasize the importance of utilizing echography to fully examine patients and initiate appropriate treatment, especially in those with a more advanced disease presentation.

Our study also investigated the relationship between treatment, echographic features, and VA outcomes in patients with endophthalmitis. The current study findings did not demonstrate a significant difference in VA outcomes when comparing the vitrectomy group and the group who did not receive vitrectomy, nor was there an association between time to vitrectomy and VA outcomes. Other studies have similarly shown no relation between early vitrectomy and VA outcomes in cohorts that included patients with multiple endophthalmitis etiologies.^{26,28} Those studies^{26,28} had a higher incidence of more virulent organisms (eg, *Streptococcus* species) compared to the Endophthalmitis Vitrectomy Study (EVS), which determined that vitrectomy achieves the best VA outcome for patients presenting with acute postcataract endophthalmitis (APCE) and worse VA (light vision).²⁹ Since the EVS study, Dib et al³⁰ reported that, among patients with APCE presenting with worse VA (HM), 88% (39 of 44) regained a VA of 20/40 or better; thus, those authors recommended use of complete and early vitrectomy for fundus-obscuring APCE. Other retrospective series have similarly supported that complete and early vitrectomy for APCE is most beneficial, with as high as 91% of patients achieving a final VA of 20/40 or better with vitrectomy.^{31–34} The difference in conclusions between these studies and the current investigation may relate to the cohort of patients, as this study includes all etiologies of endophthalmitis (not just APCE) and these patients received multiple B-scan evaluations during their care, which may be due to more advanced disease at baseline. Additionally, the risk of postoperative complications is an important factor to weigh, as their presence may lead to poor VA outcomes. Importantly, however, these complication rates

underscore the importance of weighing both the risks and benefits of surgery and monitoring for postoperative complications, specifically with echography.

This study is not without limitations. First, the retrospective nature of this study may yield missing and unavailable data, as well as unrecognized confounding variables. There is also a potential selection bias in focusing on patients who received serial B-scans, which may affect the generalizability of the findings. In obtaining the ultrasonography data, there was no standardization of interpretation across all B-scans in this study, which can result in variation in reported findings. Although only a small group of experts performed the imaging, echographic findings can be difficult to interpret and can be variable in presentation, inevitably leading to some subjectivity in B-scan interpretations. The timing of B-scans varied, with some performed after initial treatment (tap and inject or vitrectomy) and others conducted informally before treatment, potentially introducing variability in the findings. Furthermore, patients in this study who received an echographic examination as part of their care were likely to have more complicated disease, especially those who received multiple B-scans at follow-up visits. Not every patient with endophthalmitis underwent echographic examination, and therefore patients with milder presentations or less advanced echographic features may have been missed in this study.

The most prominent strengths of this study include that the sample size was large for assessing vision outcomes in patients with a rare condition, and that we were able to monitor serial B-scan findings over time.

Our data demonstrate that positive microbial cultures, specific microbial species, and advanced B-scan echographic features, such as dense vitreous opacities, choroidal detachment, and RD, are predictors of poor vision outcomes in patients with endophthalmitis. Choroidal detachment and RD were more often a delayed echographic finding, presenting most commonly at the 1-week and 1-month examinations after initial presentation, respectively. RD were also significantly more common in patients who underwent vitrectomy. This study supports the use of ultrasonography as an adjunct tool for prognostication and disease monitoring in endophthalmitis.

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Ethical Approval

This study was conducted in accordance with the Declaration of Helsinki. The collection and evaluation of patient health information was performed in a Health Insurance Portability and Accountability Act (HIPAA)–compliant manner.

Statement of Informed Consent

The informed consent requirement was waived due to the retrospective nature of the study.

Data Availability

All data generated or analyzed during this study are included in this published article.

Declaration of Conflicting Interests

Nimesh A. Patel is a consultant for Atheneum, Alcon, Allergan, Alimera, Eyepoint, Lifesciences, Genentech, Guidepoint, and Regeneron. None of the other authors declared a potential conflict of interest with respect to the research, authorship, and/or publication of this article.

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