Clinical analysis and predictive factors associated with improved visual acuity of infectious endophthalmitis

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Abstract

Background: To describe the clinical characteristics and analyze the predictive factors associated with improved visual acuity of 359 patients with infectious endophthalmitis.

Methods: This study retrospectively analyzed 359 eyes of 359 patients with infectious endophthalmitis from January 2014 to December 2018. The findings summarized some epidemiological characteristics of these patients, including age, sex, occupation, patient visit time, etiology, causative organisms, therapy and best-corrected visual acuity (BCVA). Multivariate logistic regression was performed to predict the relative factors of improved visual acuity (VA).

Results: Overall, 283 (78.83%) patients were male. The mean age was 48.0 ± 18.27 years. Ocular trauma, especially the open globe injuries (246, 68.5%) was the most common etiology of infectious endophthalmitis in this study. The etiologies of infectious endophthalmitis were open globe injuries (68.5%), intraocular surgery (22.6%), cornea ulcer-associated causes (6.7%), and endogenous causes (2.2%). In the etiology classification and visual acuity improvement group, the statistically significant difference in factors such as age, sex, patient visit time, pre-therapy VA, etc. The average Logarithm of the Minimum Angle of Resolution (logMAR) BCVA on pre-therapy was 2.28 ± 0.60, and it had significantly improved to 1.67 ± 0.83 on post-therapy (P<0.05). Logistic regression analysis showed that visit time > 7 day (P=0.034, OR=0.522, 95%CI: 0.286-0.953), pre-therapy VA ≤ logMAR 2.3 (P=0.032, OR=1.809, 95%CI: 1.052-3.110), etiology of PS (vs. PT; P=0.023, OR=2.100, 95%CI: 1.109-3.974) and etiology of CA (vs. PT; P=0.005, OR=0.202, 95%CI: 0.066-0.621) were significantly associated with improved VA after adjusting for possible confounding factors.

Conclusion: Among the patients with infectious endophthalmitis, middle-aged males, especially farmers and workers, accounted for a large proportion. Open globe injuries was the main cause and gram-positive bacteria was the major causative organisms. The final visual outcomes seem to vary according to the type of endophthalmitis, but early treatment and good initial visual acuity are important factors for visual acuity improvement.

Background

Endophthalmitis is an extremely infectious disease of intraocular tissues and even whole eyes that
can have devastating consequences. Because of the difficulty in diagnosing this disease and the low rates of bacterial culture positivity, the detection and treatment of this disease is primarily based on the doctors’ clinical experience [1-3]. With the use of effective intraocular antibiotics and advances in vitreoretinal surgery, the final visual outcome has markedly improved in cases of endophthalmitis. Nevertheless, the prognosis remains very poor, and the disease often leads to irreversible visual impairment [4]. Few studies explored the risk factors related to vision damage. Durand reported that there’s a reasonably high correlation between the visual outcome and pathogenic microbiology. **Streptococci** can produce severe endophthalmitis with a poor visual outcome, whereas coagulase-negative **staphylococci** cause milder endophthalmitis in general [5]. Yosanan et al found that the only possible predictive factor associated with improved visual outcomes was PPV within 3 days [6].

Endophthalmitis may be caused by exogenous and endogenous factors. Exogenous endophthalmitis is categorized as postsurgical, posttraumatic, or cornea ulcer-associated. In contrast, endogenous endophthalmitis is caused by blood infection or immunosuppression [7, 8]. The incidence of endophthalmitis varies by location, economy, and ethnicity. In a German study, Lothar Kraus et. al reported that endophthalmitis following open ocular injury accounted for 12% of the endophthalmitis patients studied, while 41% of the patients showed endogenous endophthalmitis [9]. In contrast, an Indian study reported that only 7.4% of 955 endophthalmitis cases had an endogenous origin, and up to 82.6% were posttraumatic in nature [10].

Moreover, the disease occurs in middle-aged male patients[2], which could have a significant impact on the patients’ family and society. Therefore, a thorough understanding of its epidemiological characteristics and the predictable factors associated with improved VA is extremely important.

**Methods**

**Ethical Approval:** This retrospective, monocentric study was conducted in accordance with the tenets of the Declaration of Helsinki of the World Medical Association, and approved by the institutional review board of Shanxi Eye Hospital. The requirement for informed consent was waived due to the retrospective nature of this study.

**Participants:** We obtained medical records corresponding to diagnostic code H44.0 of the
International Classification of Diseases Version 10 (ICD-10) and selected patients who were diagnosed with endophthalmitis between January 1, 2014, and December 31, 2018 from Shanxi eye hospital. We excluded patients who showed allergic uveitis of the lens cortex, sympathetic ophthalmia, toxic reaction syndrome of the anterior segment after intraocular surgery, various forms of autoimmune uveitis, and other forms of uveitis. We ultimately screened 359 cases involving 359 eyes among the 428 patients initially selected for the study.

**Measurements:** Patient data included time of injury (grouped by year), age (0-15, 16-30, 31-45, 46-60, 61-75, or ≥76 years), gender (male or female), marital status (married, single, divorced, or widowed), occupation (farmer, worker, office clerk, retired, student, or others), etiology (posttraumatic; postsurgical, including post-cataract, post-glaucoma, post-PPV, post-IVI; corneal ulcer-associated; and endogenous), pre-therapy visual acuity, post-therapy visual acuity, therapy modalities (medical therapy, intravitreal antibiotic injections, pars plana vitrectomy and evisceration or enucleation, and causative organisms (Gram-positive, Gram-negative, fungi, or culture-negative). Visual acuity was converted to logMAR units using an international standard visual chart. Counting fingers (CFs), hand movement (HM), light perception (LP), and no LP (NLP) were converted to 1.9 logMAR, 2.3 logMAR, 2.7 logMAR, and 3.0 logMAR, respectively [11]. Eyes that had been enucleated or eviscerated were assigned a logMAR value of 3.0 (NLP) [12].

The improved VA after treatment was considered the primary indicator. The patients were classified as having “improved” visual acuity when their post-therapy BCVA was better than pre-therapy BCVA. They were classified as “not improved” when final BCVA was stable or worse than initial BCVA[6].

We followed an endophthalmitis protocol [13-16]: All patients received topical and intravenous antibiotics. Drugs of choice included either vancomycin and/or ceftazidime, then adjust the antibiotics according to the results of bacterial culture and drug sensitivity test. (1) there are inflammatory cells++ in the anterior chamber, no hypopyon and vitreous opacity were found, which should be closely observed and combined with medical therapy (MT), defined as appropriate topical, periocular, and systemic antibiotics. (2) there are hypopyon or slight opacity of the vitreous body examined by B-ultrasound, and the fundus red light reflex can be seen, visual acuity of HM(2.3 logMAR) or better[13]...
which can be received intravitreal antibiotic injections (IVA), meanwhile combined with MT. Patients who presented with a visual acuity of light perception but also with corneal involvement precluding surgery were managed similarly. (3) Patients with visual acuity worse than HM (2.3 logMAR) and with a sufficiently clear cornea, hypopyon complicated, vitreous opacity and disappearance of red light reflex were treated with PPV as a primary procedure, including IVA and MT. If there is intraocular foreign body (IOFB), PPV should be taken first. (4) The effect of the above treatment is not effective, the corneal ulcer perforation is serious, and the patient’s vision has no light perception. Evisceration or enucleation should be considered.

**Statistical analysis:** Data were aggregated using Microsoft Excel (Microsoft Corporation, Redmond, WA, USA) and statistically analyzed using SPSS 25.0 (IBM, Inc., Armonk, NY, USA). Results of descriptive analyses were expressed as counts and percentages for categorical variables, and as mean ± standard deviation (SD) for continuous variables. Differences in the measurement data were detected by analyses using t-test or χ² test. Multivariate analysis to ascertain the identified variables on the likelihood of improved visual outcome was done using binomial logistic regression. The difference was considered significant when P-value < 0.05.

**Results**

The basic characteristics of patients with infectious endophthalmitis recruited in this retrospective study are shown in Figure 1. Altogether, 359 eyes from 359 patients were diagnosed as showing infectious endophthalmitis, and the patients were treated at our hospital within 5 years. In the five-year case counts, the overall trend showed an increase, but with a small drop in 2016 and 2017 (2014: 62, 2015: 76, 2016: 73, 2017: 68, and 2018: 80).

**Age, gender, marital status, occupation and eye characteristics**

The average age of the injured patients was 48.0±18.27 years (range, 4 to 86 years), and the median age was 48 years. The 46-60-year age group contained the most cases (108, 30.1%), followed by the 31-45-year group (92, 25.6%). Of the 359 patients, 283 were male (78.8%) and 76 were female (21.2%). The male-to-female ratio was 3.7:1. In the injured population, 77.4% (278) of the patients were married, 15.6% (56) were single, 2.5% (9) were divorced, and 4.5% (16) were widowed. The
patients were mainly involved in five kinds of occupations: farmer, worker, student, retired, office clerks, and others, with the corresponding incidence rates being 39.3%, 32.9%, 6.1%, 6.1%, 4.2%, and 11.4%, respectively. Among the 359 patients, 51.0% (176) showed only unilateral right eye involvement, 49.0% (183) showed only unilateral left eye involvement, and no one showed bilateral involvement.

**Causative organisms**

Following the onset of endophthalmitis, 316 patients (88.0%) underwent diagnostic tapping of ocular specimens for microbiological investigations, including vitreous tap and/or aqueous tap. All 316 diagnostic taps were performed at the time of initial presentation of ocular symptoms and prior to commencement of intravitreal antimicrobial therapy. The incidence of negative cultures was 55.4%, while that of positive cultures was 44.6%. Gram-positive organisms were found to be the causative microorganism in 115 eyes (81.6%), Gram-negative organisms in 16 eyes (11.3%), mixed bacterial populations in 4 eyes (2.8%), and fungi in 6 eyes (4.3%). Common pathogenic bacteria are shown in Table 1, the most common microorganisms were *Staphylococcus epidermidis* (59 cases), followed by *S. aureus* (11 cases).

**Etiological classification**

Etiological classification of endophthalmitis were demonstrated (Table 2). Table 2 shows that ocular trauma, especially open globe injury, was the most frequent cause of the disease, accounting for 68.52% of all patients. Among the 246 posttraumatic cases, 87 (35.37%) involved IOFB, 71 (28.86%) involved metals, and 16 (6.50%) involved non-metallic items, while 197 (80.08%) had zone I injuries, followed by zone II (44, 17.89%) and zone III (5, 2.03%). Post-surgical cases were the second most common, accounting for 22.6%, and included post-cataract (62.96%), post-glaucoma (24.69%), post-PPV (11.11%), and post-IVI (1.23%). Other causes were corneal ulcer-associated (CA) (6.69%) and endogenous (2.22%).

Statistical analysis of the factors among the four groups showed in Table 2. There was no significant difference in every year and affected eye among the four groups ($\chi^2$ test: $P>0.05$), but patients with endogenous endophthalmitis are more susceptible to the left eye. Age demonstrated a significant
difference among the four groups (F=43.04, P < 0.001), and the posttraumatic group (41.67±15.51 years) was younger than the other groups, while the endogenous group (67.13±16.13 years) had the oldest age. There were significantly more males (89.02%) in the posttraumatic group compared with the other groups, while the cornea ulcer-associated endophthalmitis tended to affect females (75.00%) more (χ² = 84.69, P < 0.001). There was a significant difference in occupation distribution among the four groups, and the posttraumatic group tended to have more workers (43.90%), while the other groups tended to have more farmers (38.27%, 66.67% and 50.00%, respectively, P < 0.001). Patient visit time in different group was statistically significant difference(χ²=47.41, P<0.0001). Regarding therapy modalities, PPV were the major in posttraumatic and postsurgical endophthalmitis, while enucleation accounted for the most in cornea ulcer-associated and endogenous endophthalmitis (χ²=137.3, P<0.0001). The causative organisms had significant difference among the four groups (χ²=40.20, P = 0.0004). Most of endogenous endophthalmitis tended to be caused by Gram-positive organisms (100%), while as fungus in cornea ulcer-associated group (42.86%). The pre-therapy visual acuity and post-therapy visual outcome compared in the four groups were significant difference(F=7.198, F=15.82, respectively, P<0.0001). The visual acuities were improved in 253 cases (60.2%), stable in 58 (13.8%), and worse in 109 (26%). The improvement rate of visual acuity was highest in postsurgical endophthalmitis (81.48%), while the visual acuity did not improve significantly in cornea ulcer-associated (79.17%) and endogenous (75.00%) endophthalmitis.

**Therapy modalities**

The therapy modalities are listed in Table 3. Medical therapy (MT), defined as appropriate topical, periocular, and systemic antibiotics, was used in 26 cases (7.24%). Combined vitrectomy and intraocular antibiotics were used on 243 cases (67.69%), whereas 54 (15.04%) were treated with intravitreal antibiotic injections (IVA) alone. Intravitreal antibiotics included either vancomycin and ceftazidime. Enucleation was performed in 36 cases (10.03%), ten of which had their eyes removed in a second operation. cornea ulcer-associated endophthalmitis were the most cause in the enucleation group(Table 1).
Visual outcome

Visual outcomes were assessed for 358 eyes, excluding the eye of one child who did not cooperate with the vision test. The average logMAR BCVA on pre-therapy was 2.28 ± 0.60 and the value had significantly improved to 1.67 ± 0.83 on post-therapy (t=7.161, P< 0.0001).

Pre-therapy and post-therapy VA were compared among the four groups (Gram-positive, Gram-negative, fungi, and culture-negative) are shown in Figure 2A. We observed a significant difference in visual acuity between Gram-positive(G+) and culture-negative patients at pre-therapy and post-therapy (P < 0.0001), while there was no significant difference in patients with Gram-negative(G-) bacteria and fungal infection. Figure 2B showed the statistical difference between pre-therapy and post-therapy in MT, MT+IVA and MT+IVA+PPV (P < 0.0001) while the post-therapy VA had no significant difference in these therapy modalities.

Demographic and clinical features associated with improved visual acuity are demonstrated in Table 4. There were no significant differences in average age, but significances in the segment of age and gender (P < 0.05). For eye and occupation, there are no statistically significant (P > 0.05). Patient visit time is an important statistical factor, the average visit time and time segment were statistically different in the not-improved and improved groups. It was noted that post-traumatic and post-surgical endophthalmitis had obvious improved visual outcomes compared to those having other types of endophthalmitis, and the difference was statistically significant (χ²=41.98, P<0.0001). For causative organisms, in 141 cases of positive cultures, G+ coccus showed the most favorable visual outcomes when compared to others, there was statistically significant differences (χ²=12.93, P=0.0047).

Regarding therapy modalities, PPV demonstrated more improved visual outcomes, the difference was statistically significant (χ²=87.15, P<0.0001) and the pre-therapy VA display an important role in improving vision, and the patient’s visual acuity of HM (2.3 logMAR) or better trended to statistical improved (χ²=9.00, P=0.003). Among 246 patients with post-traumatic endophthalmitis, the presence of IOFB( χ²=4.841, P<0.0001) and wound location( χ²=7.398, P=0.0247) were statistically correlated with improved VA, But there is no statistical difference between metal and non-metal IOFB. The visual improvement in zone I was significantly better than that in zone II and III.
Binomial Logistic regression analysis of predictive factors of improved VA

Multivariate analysis using binomial logistic regression model was conducted to examine the predictive factors of improved VA. After adjusting for possible confounding factors, visit time > 7 day (P=0.034, OR=0.522, 95%CI:0.286-0.953), pre-therapy VA ≤ logMAR 2.3 (P=0.032, OR=1.809, 95%CI:1.052-3.110), etiology of PS (vs. PT; P=0.023, OR=2.100, 95%CI:1.109-3.974) and etiology of CA (vs. PT; P=0.005, OR=0.202, 95%CI:0.066-0.621) were significantly associated with improved VA (Table 4).

Discussion

The present study investigate the clinical characteristics in infectious endophthalmitis of different etiology and analyse the predict factors associated with improved visual acuity of endophthalmitis patients.

In our retrospective study, the average age of patients was 48.01 ± 18.27 years, and the patients were mostly young and middle-aged, resulting in a significant impact on their families and our society, but the average age in Germany was 69.3 ± 1.7 years [15], while the average age in western China was 35.1 ± 20.3 years [2]. There are significant differences in the distribution between the gender of endophthalmitis between developed and developing countries. In developed countries, the distribution in men and women was almost the balance [3, 9], but in India [17] and China (the western region) [2], the proportion in men was significantly higher than that in women, which is consistent with our study. This is related to the fact that women rarely engage in physical activity, which results in less ocular trauma. The patients were farmers (39.3%), workers (32.9%), office clerks (4.2%), retirees (6.1%), students (16.1%), and others (11.4%). The highest proportion of patients consisted of farmers and workers, which is similar to the epidemiological characteristics in other countries [2, 15, 18]. This may be related to the fact that workers and farmers are more prone to trauma and the high-risk nature of their occupations. For injured eyes, there is no statistical difference between left and right eyes in general.

The results obtained for pathogenic bacteria are consistent with the findings of most reports. We obtained anterior aqueous humor and or vitreous fluid for bacterial culture from 316 patients, and the
culture-positive rate was 44.62%. Among the culture-positive cases, Gram-positive bacteria accounted for 81.6%, Gram-negative bacteria accounted for 11.3%, fungi accounted for 4.3%, and 4 cases (2.8%) involved mixed bacterial infections. *S. epidermidis* was the highest rate in the common pathogens, which was similar with Thailand [19] rather than *S. aureus*, which is common in other countries [15, 20]. The causative organisms is highly correlated with VA[21]. In terms of the relationship between bacteria and VA, there was a significant difference in the visual acuity between pre-therapy and post-therapy in the gram-positive and culture-negative groups, but there was no significant difference in the gram-negative and fungal infection groups, which may be related to the highly virulent and the rapid infection progress of Gram-negative bacteria and fungi and the poor therapeutic effect in these cases. Thus, the pathogenicity of the microorganisms significantly influenced the prognosis.

The etiology of the disease were divided into four groups: posttraumatic, postoperative, corneal ulcer-related, and endogenous [22], we analyzed the various factors’ difference in the four groups. In our study, posttraumatic endophthalmitis was the main cause, accounting for 68.52%, followed by 22.56% postoperative cases. A German report showed that endogenous endophthalmitis accounted for 41% of the cases [15]. In contrast, a study conducted in Odisha, India, reported that 43.0% of the cases had a postoperative etiology while 40.2% were post-traumatic [17], while one study in the western region in China reported that 82.6% of 955 endophthalmitis cases were posttraumatic. In the posttraumatic group, the patients were significantly younger, the average age was 41.67 ± 15.51 years. the average logMAR BCVA significantly improved from 2.22 ± 0.63 on pre-therapy to 1.59 ± 0.80 on post-therapy (p<0.0001), the VA improvement rate reached 67.48%, this might be related to PPV, the mainly therapy modality. About the pathogenic bacteria, Gram-positive bacteria were the most common and even multiple mixed infections existed. Wound location was dominated by zone1, and 87 cases (35.4%) were complicated with intraocular foreign bodies, including 71 cases (28.5%) of metal foreign bodies and 16 cases (6.5%) of non-metallic foreign bodies; this is similar to the findings from other countries [23, 24]. In regard to the postoperative group, the proportion of retirees and the age increased significantly, with an average age of 62.21±17.17. There was no significant difference
in the ratio of male to female. The VA improvement rate (81.48%) was the most significant among the four groups, and the treatment was also dominated by PPV. However, in the group of corneal ulcer-related endophthalmitis, the proportion of female was the highest compared with the other groups, and the pathogenic bacteria were G+ bacteria and fungi, because of the delayed visit time and the poor pre-therapy VA, the proportion of enucleation is the highest in the four types. In endogenous endophthalmitis which was caused by hematogenous spread, we not only found that the average age was the oldest and the pathogenic bacteria were all G+ bacteria, which was consistent with previous reports[7, 21], but also discovered more interesting value that the case of left eye involvement was most, and there was statistical difference with posttraumatic and postoperative group. This finding was not conformed with the previous understanding[3] that the right eye was more frequent. We analyzed that this might be related to the proximity of the left eye to the heart. But this result may not be convincing, due to the less sample sizes and the limitations of ophthalmology hospitals.

Different etiology, different visual acuity prognosis results, corneal ulcer-related endophthalmitis had the worst postoperative visual acuity (2.64±0.69). the posttraumatic and postoperative group had the improved VA significantly, while corneal ulcer-related and endogenous endophthalmitis had a higher rate of visual acuity unimproved, with statistically significant differences.

All 359 patients received topical and intravenous antibiotics, including vancomycin alone or ceftazidime in combination. All patients did not receive intraocular antibiotics before onset, but some patients had received systemic antibiotics [23]. There are different therapeutic modalities for infectious endophthalmitis according to the severity. According to our data analysis, there was a relationship between different therapy and vision improvement. According to figure 1 and table 4, in addition to enucleation, the improvement of visual acuity was statistically significant by various treatment methods, and in the PPV group was significantly higher than that in other groups, which was similar to the results of other researches[4, 6]. Therefore, PPV is the main therapy strategies in infectious endophthalmitis[4, 5, 22].

The improved VA after treatment was considered the primary outcome, so we investigated various factors that may affect the improvement of VA, including age, gender, etiology, pre-therapy VA,
patient visit time, pathogenic microorganisms, therapy modalities and etc. In the posttraumatic endophthalmitis, the presence of IOFB and wound location were associated with improved vision, but the metal or non-metal relationship was not significant. The improvement in vision in zone III was significantly worse than that in zones I and II. Finally, multivariate analysis using binomial logistic regression was performed on these factors with \( P > 0.05 \), the therapy modalities are an intermediate variable, affected by many factors, so it was not included in the regression study. We found that the patient visit time, pre-therapy VA and the etiology were important factors for visual improvement, and no correlation was found with age and pathogenic bacteria. The visual outcomes caused by different pathogenic bacteria were inconsistent, but no statistical difference was found in logistic regression analysis, which may be caused by a relatively lower bacterial positive culture rate, correlations with etiology, patient visit time, visual outcome etc.

Nevertheless, this retrospective analysis had some limitations: (1) Our study had a single-center and retrospective study design. A prospective, randomized study design would have been more desirable. (2) Shanxi Ophthalmology Hospital is the largest ophthalmology hospital in Shanxi Province. However, patients with the severe systemic disease will be referred to a general hospital; thus, we may not have obtained the data for a large number of patients with endogenous endophthalmitis, which would cause sampling bias. (3) In terms of visual acuity, we did not perform final follow-up assessments, and we only assessed the vision at a single hospitalization and discharge, because traumatic cataract and postoperative inflammatory reaction will affect vision. In future studies, we intend to collect these data.

In summary, the final visual outcomes seem to vary according to the type of endophthalmitis, but early treatment and good initial visual acuity are important factors for visual acuity improvement. In our further study, we will extend a longer follow-up time to observe more potential complications and final recover sight. Moreover, multiple imaging modalities, such as structural and functional OCT, FA, ICGA, AF etc, can be included to find more quantitative parameters in patients diagnosed with infectious endophthalmitis.

Abbreviations
BCVA: best-corrected visual acuity; VA: visual acuity; PPV: pars plana vitrectomy; CFs: counting fingers; HM: hand movement; LP: light perception; IVI: intraocular injection; MT: medical therapy; IVA: intravitreal antibiotic injections; IOPB: intraocular foreign body; CA: corneal ulcer-associated; G+: Gram-positive; G-: Gram-negative; CO: Causative organisms; TM: Therapy modalities; EC: Etiological classification; OR: Odds ratio; PT: Post-traumatic; PS: Post-surgical; PC: Post-cataract; PG: Post-Glaucoma; PP: Post-PPV; PI: Post-IVI; Ed: Endogenous.

Declarations

**Ethics approval and consent to participate**

This study was in accordance with the tenets of the Helsinki Declaration and was approved by Shanxi eye Hospital Ethics Committee.

**Consent for publication**

Not applicable.

**Availability of data and materials**

The analytical data in this study could be obtained from the corresponding author upon reasonable request.

**Competing interests**

The authors declare no conflict of interest.

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**Authors’ contributions**

HY and XMZ conceived and designed the study. ZG, YDZ and XHG collected and reviewed the
patient data. JJW, TM and GYL analyzed the data and provided interpretation. ZG was the major contributor in writing the manuscript. All authors read and approved the final manuscript.

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Tables

Table 1
Causative organisms in the 316 eyes with endophthalmitis

| Causative organisms | n(316) | Rate% | Positive rate% |
|---------------------|--------|-------|----------------|
| Culturepositive     | 141    | 44.62%| 100.00%        |
| Grampositive        | 115    | 36.39%| 81.56%         |
| S. epidermidis      | 59     | 18.67%| 41.84%         |
| S. aureus           | 11     | 3.48% | 7.80%          |
| V. Streptococci     | 9      | 2.85% | 6.38%          |
| S. pneumoniae       | 7      | 2.22% | 4.96%          |
| Enterococcus        | 7      | 2.22% | 4.96%          |
| S. mutans           | 4      | 1.27% | 2.84%          |
| T. Streptococcus    | 3      | 0.95% | 2.13%          |
| Micrococcus luteus  | 3      | 0.95% | 2.13%          |
| Bacillus spp.       | 4      | 1.27% | 2.84%          |
| Corynebacterium     | 2      | 0.63% | 1.42%          |
| others              | 6      | 1.90% | 4.26%          |
| Gramnegative        | 16     | 5.06% | 11.35%         |
| Sphingomonas        | 4      | 1.27% | 2.84%          |
| K. pneumoniae       | 2      | 0.63% | 1.42%          |
| P. aeruginosa       | 2      | 0.63% | 1.42%          |
| Dry Neisseria       | 2      | 0.63% | 1.42%          |
| S. maltophilia      | 2      | 0.63% | 1.42%          |
| others              | 4      | 1.27% | 2.84%          |
| Mixed bacteria      | 4      | 1.27% | 2.84%          |
| fungus              | 6      | 1.90% | 4.26%          |
| Culturenegative     | 175    | 55.38%|                |

Table 2
The etiological classification of infectious endophthalmitis

| Variable       | Posttraumatic | Postsurgical | Cornea ulcer-associated | Endogenous | Statistics |
|----------------|---------------|--------------|-------------------------|------------|------------|
| 246 (68.52%)   | 81 (22.56%)   | 24 (6.69%)   | 8 (2.22%)               |            |            |
| Year   | 17 (17.89%) | 16 (19.75%) | 1 (4.17%) | 1 (12.50%) | $\chi^2 = 10.28$ | 0.592 |
|--------|-------------|-------------|------------|------------|-----------------|-------|
| 2015   | 58 (23.58%) | 14 (17.28%) | 3 (12.50%) | 1 (12.50%) |                 |       |
| 2016   | 47 (19.11%) | 19 (23.46%) | 6 (25.00%) | 1 (12.50%) |                 |       |
| 2017   | 45 (18.29%) | 16 (19.75%) | 5 (20.83%) | 2 (25.00%) |                 |       |
| 2018   | 52 (21.14%) | 16 (19.75%) | 9 (37.50%) | 3 (37.50%) |                 |       |
| Age    | 41.67 ± 15.51 | 62.21 ± 17.17 | 58.67 ± 11.94 | 67.13 ± 16.13 |                 |       |
| ≤ 15   | 15 (6.10%)  | 2 (2.47%)   | 0 (0.00%)  | 0 (0.00%)  | $\chi^2 = 134.5$ | < 0.000 1 |
| 16–30  | 42 (17.07%) | 5 (6.17%)   | 0 (0.00%)  | 0 (0.00%)  |                 |       |
| 31–45  | 84 (34.15%) | 3 (3.70%)   | 4 (16.67%) | 1 (12.50%) |                 |       |
| 46–60  | 80 (32.52%) | 17 (20.99%) | 9 (37.50%) | 2 (25.00%) |                 |       |
| 61–75  | 20 (8.13%)  | 33 (40.74%) | 10 (41.67%)| 2 (25.00%) |                 |       |
| > 75   | 5 (2.03%)   | 21 (25.93%) | 1 (4.17%)  | 3 (37.50%) |                 |       |
| Gender | male        | female      |            |            |                 |       |
|        | 219 (89.02%)| 27 (10.98%) | 18 (75.00%)| 4 (50.00%) | $\chi^2 = 84.69$ | < 0.000 1 |
|        | 42 (51.85%) | 39 (48.15%) | 16 (66.67%) | 4 (50.00%) | $\chi^2 = 102.7$ | < 0.000 1 |
|        | 108 (43.90%)| 9 (11.11%)  | 1 (4.17%)  | 0 (0.00%)  |                 |       |
|        | 20 (8.13%)  | 2 (2.47%)   | 0 (0.00%)  | 0 (0.00%)  |                 |       |
|        | 1 (0.41%)   | 16 (19.75%) | 4 (16.67%) | 1 (12.50%) |                 |       |
|        | 10 (4.07%)  | 4 (4.94%)   | 1 (4.17%)  | 0 (0.00%)  |                 |       |
|        | 17 (6.91%)  | 19 (23.46%) | 2 (8.33%)  | 3 (37.50%) |                 |       |
| Eye    | Right       | Left        |            |            |                 |       |
|        | 131 (53.25%)| 115 (46.75%)| 6 (25.00%) | 1 (12.50%) | $\chi^2 = 6.61$ | 0.085 |
|        | 48 (59.26%) | 33 (40.74%) | 12 (50.00%)| 7 (87.50%) |                 |       |
|        | 12 (50.00%) | 12 (50.00%) | 6 (25.00%) | 6 (75.00%) | $\chi^2 = 47.41$ | < 0.000 1 |
|        | 21 (25.93%) | 18 (75.00%) | 2 (25.00%) |            |                 |       |
|        | MT          | MT + IVA    | MT + IVA + PPV | Enucleation | CO culture (+)* |         |
|        | 13 (5.28%)  | 9 (11.11%)  | 3 (12.50%) | 1 (12.50%) |                 |       |
|        | 36 (14.63%) | 14 (17.28%) | 2 (8.33%)  | 2 (25.00%) | $\chi^2 = 137.3$ | < 0.000 1 |
|        | 186 (75.61%)| 53 (65.43%) | 1 (4.17%)  | 2 (25.00%) |                 |       |
|        | 11 (4.47%)  | 5 (6.17%)   | 18 (75.00%)| 3 (37.50%) |                 |       |
|        | 90 (40.72%) | 40 (54.05%) | 7 (58.33%) | 4 (50.00%) |                 |       |
|        | 74 (82.22%) | 33 (82.5%)  | 4 (57.14%) | 4 (100.00%)| $\chi^2 = 40.42$ | 0.000 4 |
|        | 9 (10.00%)  | 7 (17.5%)   | 0 (0.00%)  | 0 (0.00%)  |                 |       |
### Table 3

| Therapy modalities | n   | Rate% |
|--------------------|-----|-------|
| 1 MT               | 26  | 7.24% |
| 2 MT + IVA         | 54  | 15.04%|
| 3 MT + IVA + PPV   | 243 | 67.69%|
| 4 Enucleation      | 36  | 10.03%|
| Total              | 359 | 100.0%|

MT: medical therapy. IVA: intravitreal antibiotic injections. PPV: pars plana vitrectomy.

### Table 4

| Factors | Not improved | Improved | t/χ² | P  | Multivariable analysis |
|---------|--------------|----------|------|----|------------------------|
|        | (120)        | (238)    |      |    | OR(95%CI) P             |
| Age     |              |          |      |    |                        |
| 0–15    | 1(0.83%)     | 15(6.30%)| t = 0.595 | 0.552 | 0.00(Reference) |
| 16–30   | 24(20.00%)   | 23(9.66%)| χ² = 14.30 | 0.014 | 0.462(0.110–1.950) 0.293 |
| 31–45   | 31(25.83%)   | 61(25.63%)|     |    | 0.434(0.110–1.726) 0.234 |
| ≥ 46    |              |          |      |    |                        |

Patient demographic characteristics of multivariable logistic regression analysis of the factors associated with improved visual acuity in 358 cases.
| Group   | n     | (%)  | Reference | \( \chi^2 \)   | df | p-Value |
|---------|-------|------|-----------|-----------------|----|---------|
| \( 46-60 \) | 31(25.83%) | / / (32.35%) | | 0.557 (0.143–2.169) | 1 | 0.742 (0.181–3.034) |
| > 75    | 8(6.67%) | 22(9.24%) | 0.400 (0.088–1.813) | 1 | 0.235 |
| Gender  | Male | 102(85.00%) | 180(75.63%) | \( \chi^2 = 4.188 \) | 1 | 0.041 |
|         | Female | 18(15.00%) | 58(24.37%) | 1.387 (0.719–2.675) | 1 | 0.329 |
| Occupation | Farmer | 50(41.67%) | 91(38.24%) | \( \chi^2 = 3.825 \) | 1 | 0.0575 |
|         | Worker | 40(33.33%) | 78(32.77%) | 2.100 (1.109–3.974) | 1 | 0.023 |
|         | Student | 4(3.33%) | 17(7.14%) | 0.202 (0.066–0.621) | 1 | 0.005 |
|         | The retired | 5(4.17%) | 17(7.14%) | 0.194 (0.086–0.953) | 1 | 0.053 |
|         | Office clerks | 6(5.00%) | 9(3.78%) | 0.00 (Reference) |
|         | Others | 15(12.50%) | 26(10.92%) | - |
| Eye     | Right | 58(48.33%) | 118(49.58%) | \( \chi^2 = 0.0496 \) | 1 | 0.824 |
|         | Left  | 62(51.67%) | 120(50.42%) | 2.654 | 0.0083 |
| Visit time | \( \leq 7D \) | 85(70.83%) | 194(81.51%) | \( \chi^2 = 5.290 \) | 1 | 0.0214 |
|         | 35(29.17%) | 44(18.49%) | 0.00 (Reference) |
| EC      | PT | 80(66.67%) | 166(69.75%) | \( \chi^2 = 41.98 \) < 0.0001 | 1 | 0.00 (Reference) |
|         | PS | 15(12.50%) | 65(27.31%) | 2.100 (1.109–3.974) | 1 | 0.023 |
|         | CA | 19(15.83%) | 5(2.10%) | 0.202 (0.066–0.621) | 1 | 0.005 |
|         | Ed | 6(5.00%) | 2(0.84%) | 0.194 (0.086–0.953) | 1 | 0.053 |
| Pre-therapy VA | 2.28 ± 0.60 | 1.67 ± 0.83 | t = 7.161 < 0.0001 | 1 | 0.00 (Reference) |
|         | \( > \log MAR2.3 \) | 60(50.00%) | 79(33.19%) | \( \chi^2 = 9.00 \) | 1 | 0.003 |
|         | \( \leq \log MAR2.3 \) | 60(50.00%) | 159(66.81%) | 1.809 (1.052–3.100) | 1 | 0.032 |
| TM      | MD | 4(3.33%) | 22(9.24%) | \( \chi^2 = 87.15 \) < 0.0001 | 1 | - |
|         | MD + IVI | 23(19.17%) | 31(13.03%) | 87.15 < 0.0001 | 1 | 0.00 (Reference) |
|         | MD + IVI + PPV | 57(47.50%) | 185(77.73%) | - |
|         | Enucleation | 36(30.00%) | 0(0.00%) | 0.00 (Reference) |
|         | CO | 49 | 92 | - |
| Culture(+) | 35(71.43%) | 80(88.24%) | \( \chi^2 = 12.93 \) | 1 | 0.0047 |
|         | G- bacteria | 7(14.29%) | 9(8.24%) | 0.00 (Reference) |
|         | Mixed bacteria | 1(2.04%) | 3(3.53%) | - |
|         | fungus | 6(12.24%) | 0(0.00%) | - |
|         | IOFB* | 44(55.00%) | 115(69.28%) | \( \chi^2 = 4.814 \) | 1 | 0.0282 |
|         | Yes | 36(45.00%) | 51(30.72%) | - |
|         | Metal | 27(75.00%) | 44(86.27%) | \( \chi^2 = 1.787 \) | 1 | 0.1812 |
|         | Non-metal | 9(25.00%) | 7(13.73%) | - |
| Wound location* | 80 | 166 | \( \chi^2 = 7.398 \) | 1 | 0.0247 |
|         | Zone I | 58(72.50%) | 139(83.73%) | 0.00 (Reference) |
|         | Zone II | 18(22.50%) | 26(15.66%) | - |
|         | Zone III | 4(5.00%) | 1(0.60%) | - |

*246 cases of posttraumatic endophthalmitis were included in the \( \chi^2 \) test, but not the Logistic regression analysis.
**141 cases of positive causative organisms cultures were included in the \( \chi^2 \) test, but not the Logistic regression analysis.

TM: Therapy modalities. EC: Etiological classification. CO: Causative organisms. OR: Odds ratio. PT: Post-traumatic. PS: Post-surgical. PC: Post-cataract. PG: Post-Glaucoma. PP: Post-PPV. PI: Post-IVI. CA: Cornea ulcer-associated. Ed: Endogenous. 2: MT + IVA. 3: PPV + IVA + MT.
Figure 1

Characteristics of patients with infectious endophthalmitis in Shanxi Eye Hospital, China from 2014 to 2018

Figure 2

Comparison of pre-therapy BCVA and post-therapy BCVA between difference causative bacteria (A) and therapy modalities(B). *Using analysis of variance (ANOVA), P-value between pre-therapy BCVA and post-therapy BCVA P < 0.05. (1:MT, 2. MT+IVA. 3:MT+IVA+PPV. 4: Enucleation.)
