*Review Article*

Endophthalmitis in Silicone Oil-Filled Eyes: A Narrative Review

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ABSTRACT

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| **Aims:**  This narrative review aims to examine the current knowledge relating the management of endophthalmitis in eyes filled with silicone oil, by analyzing available therapeutic strategies, reported clinical outcomes and the specific challenges inherent to this particular context. **Study design:** narrative review based on a critical synthesis of published clinical and experimental data.**Place and Duration of Study:** Conducted at the Department of Ophthalmology, University Hospital Hassan II of Fez. Literature analyzed covered the period from January 2000 to March 2025.**Methodology:** A Systematic search of the PubMed, Scopus and Google Scholar databases was carried to identify publications written in English or French that specifically addressed endophthalmitis in the context of silicone oil tamponade. Studies included randomized and non-randomized trials, clinical case series, systematic reviews, and cohort studies. only articles providing detailed information on diagnostic approaches, therapeutic protocols, and clinical outcomes were integrated. A total of 221 publications were initially identified. Data were synthesized narratively. **Results:** Although rare, endophthalmitis in silicone oil filled eyes constitutes a major diagnostic and therapeutic challenge. The antimicrobial properties of silicone oil, while suggested by experimental and clinical findings, remain variable depending to the pathogen. Key risk factors include unsutured sclerotomies, combined procedures, and anatomical variables. The clinical presentation is often atypical, complicating early detection. culture positivity remains low, with coagulase negative Staphylococcus species being the most frequently isolated pathogens. The mainstay of treatment consists of silicone oil removal, intravitreal antibiotic injection and, in selected cases, reinjection of silicone oil. Pharmacokinetic studies suggest altered antibiotic behavior in oil filled eyes, requiring dosage adjustments. Despite adequate treatment, visual outcomes are often limited.**Conclusion:** The rapid adaptation of therapeutic based on cultures results, antibiotic sensitivity profiles, and the clinical response remains crucial in the management of infectious endophthalmitis occurring in eyes tamponaded by silicone oil. Although available data are mainly derived from retrospective analyzes and isolated cases reports, they highlight the importance of early intervention and tailored management. Larger prospective studies are necessary to optimize diagnostic and therapeutic protocols and improve visual prognosis.  |

*Keywords: Endophthalmitis; silicone oil; vitrectomy, antibiotics*

1. INTRODUCTION

**Endophthalmitis is one of the most feared complications in ophthalmology, often occurring after intraocular surgery, intravitreal injections or ocular trauma. The increasing use of silicone oil as a tamponade agent in complex retinal interventions presents a unique set of challenges by altering the intraocular environment and the the the associated pathophysiological responses (1).**

**Indeed, although the incidence of Endophthalmitis in eyes filled with silicone oil is extremely low - generally estimated between 0.02 % and 0.13 % - its diagnosis is particularly complex due the alterations induced by this type of tamponade (2). No case of Endophthalmitis was identified by the pan American collaborative Retina Study Group, which analyzed 7,357 treated eyes, thereby illustrating the rarity of this complication (3). However, the dissemination of pathogens, the expression of inflammation, and the response to antibiotics may be altered, making early detection of infection more difficult. Clinical signs can be attenuated or distorted by the presence of silicone oil (1).**

**Management of this situation is frequently based on the removal of silicone oil and the targeted administration of intravitreal antibiotics, with, in some cases, reinjection of silicone oil once the infection is under control. The absence of standardized protocols - a consequence of the rarity of cases and the variability of clinical presentations - contributes to the complexity of treatment. Despite aggressive medical and surgical interventions, severe visual loss can occur within just a few days (2).**

**This narrative review aims to examine the current knowledge regarding the management of endophthalmitis in eyes filled with silicone oil by analyzing available therapeutic strategies, reported clinical outcomes, and the specific challenges inherent to this context. The main objective is to clarify the underlying mechanisms in order to refine diagnostic and therapeutic approaches and reduce the risk of irreversible visual deterioration.**

1. material and methods

**This narrative study is based on a comprehensive review of the scientific literature concerning the management of endophthalmitis in eyes filled with silicone oil. A systematic search was conducted using the PubMed, Scopus, and Google Scholar databases, with the aim of identifying relevant publications published between January 2000 and March 2025.**

**Only studies written in English or French were included. Selected articles had to specifically address the management of this complication in the context of silicone oil tamponade. A wide range of methodologies was considered, including randomized controlled trials, non-randomized trials, clinical case series, systematic reviews, meta-analyses, as well as observational and cohort studies.**

**To ensure relevance, only articles providing detailed information on diagnostic approaches, therapeutic protocols, and clinical outcomes were retained. The keywords used were “Endophthalmitis”, “Silicone Oil”, “Surgery”, and “Retinal Detachment”, combined using the Boolean operators "AND" and "OR". This search strategy initially identified 221 articles.**

**Each publication was rigorously examined, and bibliographies were cross-referenced. Studies that addressed the association between endophthalmitis and silicone oil without focusing on management strategies were excluded. Furthermore, publications dated prior to 2000 or presenting significant methodological limitations—such as small sample sizes or poorly defined protocols—were also excluded.**

**The Data extracted from each study included the following:**

* **Patient characteristics: age, sex, and relevant medical or surgical history.**
* **Infection context: origin of endophthalmitis (post-surgical, traumatic, endogenous, etc.) and time to onset.**
* **Diagnostic modalities: results of microbiological cultures, imaging techniques, and laboratory tests.**
* **Therapeutic approaches: types of antibiotics used (intravenous, intravitreal, or oral), indications for vitrectomy, and strategies for silicone oil removal or reinjection.**
* **Clinical outcomes: changes in visual acuity, infection resolution rates, potential complications, and the need for further surgical interventions.**

**All information was synthesized narratively. The objective was to highlight the main therapeutic strategies, reported clinical outcomes, and the specific challenges encountered in the management of this rare but serious complication.**

1. results and discussion

**Endophthalmitis in eyes filled with silicone oil remains a rare condition. However, it constitutes a major diagnostic and therapeutic challenge in ophthalmology. Although silicone oil plays a crucial role in complex retinal surgeries, its presence profoundly alters the intraocular environment, potentially affecting both the dissemination of infectious agents and the effectiveness of treatments.**

**Silicone oils are transparent, inert, and hydrophobic polymers composed of siloxane chains (Si-O) (4). Their use has become well established in the management of complex retinal detachments, particularly in cases of proliferative vitreoretinopathy, severe ocular trauma or viral retinitis (5). Furthermore, their application has been extended to certain cases of severe infectious endophthalmitis, contributing to the management of particularly challenging clinical situations.**

* 1. ****Antimicrobial properties and action mechanisms****

**Antimicrobial and fungistatic effects have been observed with silicone oil, as demonstrated by several experimental studies. Various pathogens have been investigated, including Staphylococcus aureus, Staphylococcus epidermidis, pseudomonas aeruginosa, Candida albicans and Aspergillus spp (2) (6). These effects are attributed to direct interactions with microbial cell membranes, resulting in altered membrane integrity and inhibited proliferation.**

**The absence of endophthalmitis reported by the Pan American collaborative Retina Study Group - following the analysis of 7,357 eyes treated with silicone oil - has been interpreted as further evidence supporting its potential antimicrobial activity in vivo (3).**

**Several mechanisms have been proposed to explain this effect, including the limitation of nutrient availability and the potential cytotoxicity of certain low molecular weight components of silicone oil on microbial membranes (7) (8).**

**The specific physical properties of silicone oil have also been highlighted: Its high surface tension and low permeability may impede the mobility of infectious agents, favoring their confinement in areas where the local immune response is more effective (9) (2). Additionally, the prolonged presence of silicone oil may act as a barrier, promoting the gradual elimination of pathogens and their toxins (2).**

**However, the antimicrobial efficiency of silicone oil is not uniform. In vitro studies have shown that certain anaerobic pathogens, particularly Propionibacterium acnes - the primary microorganism associated with chronic postoperative endophthalmitis - remain viable in the presence of silicone oil (10). This resistance may be linked to the capacity of P. Acnes to form biofilms and produce propionic acid, whose interactions with silicone oil still requires further investigation.**

**A comparison between conventional silicone oil and heavy silicone, conducted by Ornek and collaborators, revealed increased antimicrobial activity of heavy silicone, particularly against Candida Albicans (11). This finding suggests that formulation differences, such as enhanced hydrophobic interactions and specific hydrogen bonding, may play a decisive role. Nevertheless, a recent systematic review underscores the limited efficacy of silicone oil against certain fungal species, such as Fusarium spp., highlighting the need for continued research to optimize the use of these agents (12) (2).**

* 1. ****Risk factors****

**Endophthalmitis following pars plana vitrectomy (VPP) may results from anatomical or procedural factors that facilitate microbial infiltration. Among these, the absence of sutures when closing the surgical wounds represents a critical variable, as it promotes leakage and microbial entry (13). Comparative studies have shown that unsutured closure of sclerotomies significantly increases the risk of endophthalmitis, by up to 25 times in some reports, particularly when balanced saline solution is used as a tamponade agent (14).**

**The configuration of the incision also plays a crucial role. Straight incisions, due to their lower structural stability, are associated with an incidence of endophthalmitis ranging from 0.18 %to 0.23 %. In contrast, beveled (or oblique) incisions, which ensure a more watertight closure, are linked to significantly lower rates (ranging from 0 to 0.075 %) (15). External factors, such as eye rubbing or the presence of a vitreous wick at the sclerotomy site, can further increase this risk by inducing wound deformation (2).**

**The use of intravitreal adjuvants, particularly vascular endothelial growth factor (VEGF) antagonists, which may modulate the immune response, also appears to contribute to an increased risk infection, especially when combined with straight sclerotomy incisions (2) (1).**

**In addition, combined surgery, such as the association VPP with phacoemulsification or glaucoma filtering procedures, have been examined in various clinical contexts (16) (17). Some studies suggest an increased risk of endophthalmitis in such configurations. For instance, a retrospective multicenter analysis conducted over five years in Latin America reported incidence of 0.028 % and 0.021 % for small gauge vitrectomies (23 and 25 gauge, respectively) performed without phacoemulsification (18).**

**Paradoxically, a study by Parolini et al. reported no cases of endophthalmitis among 943 eyes that underwent 23- gauge vitrectomy, a significant proportion of which also underwent phacoemulsification with intraocular lens implantation (19). Conversely, Chen et al. observed a slight increase in the incidence of endophthalmitis when phacoemulsification was combined with a caliber 25- gauge vitrectomy, although the small sample size limits the generalizability of this finding (20). Other studies, such as that of Shimada et al., Confirm a very low incidence rate (0.0299 %) for 25 -gauge procedures (1).**

**Finally, rigorous preventive measures remain essential. The administration of subconjunctival antibiotics, conjunctival irrigation, adequate excision of the peripheral vitreous, and the use of air tamponade at the end of the procedure are all strategies aimed at reducing the risk of postoperative endophthalmitis (21).**

* 1. ****Clinical finding****

**The distinction between sterile inflammation and infectious endophthalmitis in the context of vitreoretinal surgery with silicone oil tamponade remains particularly complex, especially when the postoperative inflammatory response is exacerbated. Indeed, the presence of intraocular fibrin associated with hypopyon may occur in the absence of an actual infection, particularly following additional procedures such as lensectomy or endolaser treatment (22) (23) (24). This clinical presentation, which can mimic that of infectious endophthalmitis despite negative culture results, may lower the index of suspicion in surgeons unfamiliar with this scenario.**

**The clinical manifestations observed in patients are varied. Ocular pain is frequently reported, although some patients remain asymptomatic. Conjunctival redness is also commonly observed, often associated with anterior chamber inflammation. This may present as cellular activity, keratic precipitates, and, in some cases, the presence of fibrin or hypopyon. Fundus Examination is sometimes impeded by media opacities, limiting visualization. When feasible, examination may reveal retinal hemorrhages and whitish material or exudates on the retinal surface.**

**A recent case reported by Yan HC illustrates these diagnostic challenges: the patient presented, the day after surgery with ocular pain and decreased vision. Although the anterior chamber** **culture remained negative, all clinical signs strongly suggested infectious endophthalmitis. This case highlights the complexity of diagnosis when microbiological evidence does not corroborate the clinical suspicion.**

**Other associated manifestations may include eyelid swelling, ptosis, chemosis, corneal opacity or edema, and cataract development (24) (25). Moreover, symptoms typically appear within the first week following surgery in approximately 80 % of cases, and after one month in the remaining 10 %. Visual impairment is often severe, with acuity reduced to finger counting in 18 % of cases, hand motion perception in 73 %, or mere light perception in 9 % (25).**

* 1. ****Culture positivity rates and pathogens****
		1. ****Microbiological results and pathogenic profile****

**Culture positivity in cases of endophthalmitis occurring in eyes filled with silicone oil remains relatively low, according to the literature (26). several cases were identified, while the largest published study noted a predominance of coagulase-negative Staphylococcus species (25). These bacteria, commonly part of the normal ocular flora, highlight the importance of thorough preoperative evaluation, meticulous surgical field preparation, and vigilant postoperative monitoring to prevent their introduction into the intraocular cavity.**

* + 1. ****Therapeutic approaches****

**Zimmer-Galler and collaborators described the case of a patient with acquired immunodeficiency syndrome who developed a second retinal detachment due to cytomegalovirus retinopathy, and subsequently presented with endophthalmitis three weeks after a pars plana vitrectomy with silicone oil tamponade. cultures from the anterior chamber revealed the presence of coagulase-negative Staphylococcus (27). Removal of the silicone oil, combined with the administration of intravitreal antibiotics and reinjection of silicone oil, led to infection resolution and an improvement in visual acuity to 20/100.**

**Furthermore, Gentile et al. suggest that most endophthalmic infections are caused by Gram-positive bacteria (85.1 %), with Staphylococcus epidermidis being the most frequently isolated agent (2). In contrast, Sborgia et al. observed that only 38 % of samples from eyes filled with silicone oil tested positive for microbial growth—most of which were obtained from the aqueous humor, while 62 % remained culture- negative (1). Additionally, Steinmetz et al. described two cases in which, despite negative cultures, the use of intravitreal antibiotics led to the resolution of symptoms within one week (28).**

* + 1. ****Less frequent and unusual pathogens****

**While Pseudomonas Aeruginosa is a recognized pathogen in endophthalmitis, the involvement of Burkholderia Cepacia remains exceptionally rare. For example, Chong et al. reported a case of endophthalmitis attributed to P. aeruginosa in an eye tamponaded with silicone oil. In this case, the anterior segment was clear and free of Hypopyon, with inflammatory material confined to the retinal surface. Despite removal of the silicone oil and administration of antibiotics, the eye became hypotonous, ultimately resulting in the loss of light perception (29).**

**In a unique report, Okonkwo described the development of endophthalmitis in five eyes of five patients following pars plana vitrectomy with silicone oil tamponade. gram -negative bacilli** **were isolated, including Burkholderia Cepacia in three cases and Pseudomonas Aeruginosa in one, marking the first documented observation of B. Cepacia as a colonizer in this context, despite the presumed anti-microbial properties of silicone oil against P. aeruginosa (24).**

**Finally, although very rare, mucormycosis has also been reported as an etiology of endophthalmitis in immunocompetent patients. Traditionally associated with filamentous fungi such as Aspergillus, fungal endophthalmitis may also be caused by Mucor, as demonstrated by two reported cases in poorly controlled diabetic patients (30).**

* 1. ****Management****
		1. ****Key principles in the management of Endophthalmitis****

**The management of endophthalmitis is based on three complementary pillars: eradication of the infection, control of inflammation, and prevention of recurrence (31). Intravitreal antibiotic administration remains the gold standard treatment, as demonstrated by the Endophthalmitis Vitectomy Study (1995), a landmark reference in the management of postoperative infections, particularly following cataract surgery (32). the most frequently used agents** **include:**

* **Vancomycin (1 mg/0.1 ml), primarily targeting Gram positive bacteria.**
* **Ceftazidime (2.25 mg/0.1 ml) or amikacin (0.4 mg/0.1 ml), used for coverage of gram negative bacteria.**
	+ 1. ****Antibiotic administration strategies in the presence of silicone oil****

**Silicone oil tamponade presents specific challenges, as it hinders both the collection of vitreous samples and the homogeneous diffusion of antibiotics within the vitreous cavity. In cases where tamponade is not absolutely necessary, the recommended strategy involves removing the oil prior to intravitreal antibiotic injection into a liquefied vitreous (2).**

**However, when prolonged tamponade is essential, a staged approach has proven effective. This consists of injecting the antibiotic into the liquid vitreous, followed by air-fluid exchange (approximately 80%) after 15 minutes, before reintroducing silicone oil. This technique allows antibiotic to reach equilibrium during the initial 15 minutes, ensuring that approximately 20% of its concentration remains active after the tamponade is restored (8).**

**An alternative strategy involves enriching the infusion fluid used during vitrectomy with antibiotics, immediately after intraocular samples have been collected. Notably, Steinmetz et al. were among the first to demonstrate that intravitreal antibiotics injection in eyes filled with silicone oil enables prolonged drug release, thereby contributing to improved infection control (33).**

* + 1. ****Dosages, pharmacokinetics and toxicity considerations****

**To date, the optimization of intravitreal antibiotic dosages in the presence of silicone oil has not been standardized, and no clear consensus has been established. Preclinical studies have shown that administering full or half doses of vancomycin, ceftazidime or ganciclovir may induce retinal toxicity, whereas one-quarter of the standard dose appears to be safe (34).**

**Research conducted in macaques has demonstrated that, in eyes filled with silicone oil, vancomycin (1 mg/0.1 ml) and ceftazidime (2 mg/0.1 ml) reach significantly higher peak concentrations in the aqueous humor (543.5 μg/ml and 1176.3 μg/ml respectively) within shorter times (6.8 h and 3.1 h) Compared to normal eyes (151.4 μg/ml and 64.6 μg/ml with half-lives of 29.4 h and 20.4 h, respectively) (35). Pharmacokinetic simulations have confirmed these findings, showing peaks concentrations of 1250 μg/ml with a half-life of 3.3 h in oil-filled eyes, compared to 322 μg/ml and 12.8 h in non-buffered eyes (36). Although these results are promising, their extrapolation to human clinical practice must be approached with cautious.**

**Additional investigations, particularly those by Al Taisan et al. In rabbits and Imamura et al. In macaques, have assessed the retinal toxicity of these antibiotics (35) (26). While some studies report toxicity at full or half doses, others observed no significant changes in the electroretinographic parameters, even at full dose, in silicone oil filled eyes (32). The observed reduction in half-life under these conditions suggests accelerated drug clearance, which may justify a higher frequency of intravitreal injections compared to non-buffered eyes.**

* + 1. ****Alternative approaches and antibiotic resistance****

**A retrospective study conducted in India on more than 100,000 vitrectomies highlighted that many culture-negative cases, still responded favorably to intravitreal antibiotic injections, with notable improvements in anatomical and visual outcomes (37). However, it is essential to emphasize that endophthalmitis in silicone oil–filled eyes represents a distinct clinical entity. As such, targeted studies are needed to determine whether findings from broader populations are applicable to this specific subgroup.**

**Concurrently, the progressive rise in antibiotic resistance- particularly to Amikacin and Ceftazidime, is becoming an increasing concern in the treatment of Gram -negative endophthalmitis. Pseudomonas aeruginosa exemplifies this issue, as it rapidly develops resistance mechanisms, including beta-lactamase production. In this context, the combination of piperacillin and tazobactam has generated growing interest. Both Experimental studies, and clinical case reports, have demonstrated that the intravitreal injection of this antibiotic combination is effective and well tolerated, even in patients with resistant infections (38) (39) (40) (41).**

* + 1. ****Systemic antibiotic therapy****

**The use of systemic antibiotics in addition to intravitreal treatment remains a controversial strategy. Indeed, the penetration of antibiotics into intraocular tissues is often limited by physiological barriers such as the blood-retinal barrier, the retinal pigment epithelium, and the retinal endothelium (42) (43). These limitations justify the predominance of the intravitreal route to achieve adequate therapeutic concentrations.**

**However, some studies, such as that by Talwar et al., Have indicated that effective levels of ciprofloxacin could be achieved in the retro-silicone space following oral administration, exceeding the MIC90 for most bacteria (44).**

**Despite the lack of definitive evidence and the absence of uniform guidelines, systemic antibiotic prescriptions remain common, driven by the severity of the infectious condition. Nonetheless, this practice raises concerns related to antimicrobial stewardship, particularly regarding potential overuse or suboptimal therapeutic management.**

**The landmark Endophthalmitis Vitectomy Study of 1995 had already concluded that systemic administration of Ceftazidime (2 g every 8 hours) and Amikacin (7.5 mg/kg initially, then 6 mg/kg every 12 hours) did not significantly improve final visual outcomes . In contrast, more recent protocols incorporating fourth generation fluoroquinolones, meropenem or linezolid appear capable of achieving therapeutic intravitreal concentrations (42) (45) (46).**

* 1. ****Future perspectives****

**Advances in ophthalmic drug delivery systems are paving the way for improved antibiotic penetration, bioavailability, and therapeutic efficacy. These innovations may offer less invasive and safer alternatives for patients, while enhancing the management of this challenging complication. Until such approaches are validated and widely adopted, intravitreal injections remain the cornerstone of therapy for endophthalmitis, especially in the context of eyes filled with silicone oil.**

1. Prognosis

**Visual outcomes in patients with endophthalmitis following vitrectomy are generally poor, partly due to preexisting retinal pathology and limited baseline visual potential (47) (48). The rarity of endophthalmitis in silicone oil–filled eyes complicates efforts to establish definitive prognostic trends. Overall, fewer than 28 % of patients recover visual acuity of 20/50 or better (2).**

**A multicenter retrospective study conducted across five retinal referral centers in the United States over a four-year period, evaluated 70 patients treated with pars plana vitrectomy for acute endophthalmitis (49). Among these, 15 eyes received silicone oil during the procedure. At follow -up, with the exception of a one patient who maintained a visual acuity of 20/40 with an attached retina, the vast majority of patients had extremely limited vision, ranging from finger counting to no light perception (NPL) (49).**

**As with any infection, prognosis largely depends on the virulence of the causative agent and its antibiotic sensitivity profile. Other contributing factors, include associated retinal detachment, advanced proliferative vitreoretinopathy, ocular hypotony, phthisis bulbi or corneal opacification, all of which may significantly impact the final outcome (50). on average, only about 28 % of patients regain a visual acuity of 20/50 or better on the Snellen scale (1).**

**The literature on infectious endophthalmitis in silicone oil filled eyes supports a standard management strategy that includes surgical re -intervention to remove the oil, intravitreal antibiotic injections and in some cases, subsequent reinjection of silicone oil (1) (2). However, A recent case report, describing ambulatory intravitreal injections as an alternative approach invites a more nuanced interpretation of treatment pathways. In the most severe cases, evisceration or enucleation may remain the only recourse. Meanwhile, the use of systemic antibiotics continues to be debated, given the limited level of supporting evidence.**

1. Conclusion

**The rapid adaptation of therapeutic strategies based on culture results, antibiotic sensitivity profiles, and clinical response remains essential in the management of infectious endophthalmitis occurring in eyes tamponaded with silicone oil. Although available data are largely derived from retrospective studies and case reports - reflecting the rarity of this clinical entity- they consistently indicate a generally guarded visual prognosis.**

**Despite inherent limitations, including small sample sizes and heterogeneous methodological designs, these studies significantly contribute to improving our understanding of this complication. Ongoing research, particularly through larger-scale prospective studies, is essential to refine management protocols and ultimately enhance visual outcomes for affected patients.**

Ethical approval

All authors hereby declare that all experiments have been examined and approved by the appropriate ethics committee and have therefore been performed in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki.”

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