PERSPECTIVE

Infectious endophthalmitis after cataract surgery

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Endophthalmitis is potentially the most devastating complication of cataract surgery. For the purpose of this perspective it will be defined as intraocular infection attributed to elective cataract extraction with or without intraocular lens implantation. Ideally, all cases of endophthalmitis would be culture proved but culture negative cases that respond to antibiotic therapy are presumed to be infectious in origin despite lack of definitive proof. To this end, truly sterile postoperative inflammation resulting from phacoanaphylaxis is excluded. However, in phacoanaphylaxis it has been postulated that bacteria act as an adjuvant in stimulating a response to lens protein.[1] Additionally, the exaggerated uveitic response resulting from excessive manipulation or the introduction of foreign material will also be excluded.

There are many controversies and ambiguities in the area of postoperative endophthalmitis, particularly in relation to prevention and management. These usually reflect the large numbers required to make meaningful statements or the assumptions made in extrapolating from animal models to the infected pseudophakic eye. Within the constraints of this article six questions will be asked:

What is the incidence?
What are the causes?
How does it present?
How can it be managed?
What is the outcome?
How can it be prevented?

What is the incidence?

Most authors are agreed that the incidence of endophthalmitis following cataract surgery is declining. Good historical perspectives are provided by Forster,[2] Kattan *et al*,[3] and Fahmy.[4] It would appear that during this century the incidence has fallen from 1·5% to the region of 0·1%. This improvement has been attributed to better instrumentation allowing more precise surgery, improved operating theatre technique and the use of prophylactic antibiotics.[2 5] The incidence derived from classic studies[6] may not relate to modern surgical practice. It is important to know the incidence in relation to current techniques of extracapsular extraction or phacoemulsification with or without lens implantation. The effect of any modification or new procedure has to be related to this figure. Additionally, the rate following secondary lens implantation seems to be higher (0·3%).[3] In any study it is difficult to control for all the possible variables — for instance, the type of conjunctival flap,[7] the use and choice of prophylactic antibiotics, and the composition of the implant.[8] However, no matter how good the technique endophthalmitis will inevitably appear.

It is possible that the true incidence is higher than suspected from studies because of underreporting.[2] This could be particularly true of chronic infection which may be treated as persistent uveitis.[1] While phacoanaphylaxis may cause chronic inflammation, in the first instance endophthalmitis should be suspected.

In order to get the best modern estimate, an average has been calculated from recent published series. Unfortunately there are no modern series relating to practice in the British Isles and American studies form the basis of the estimate. This is unsatisfactory as there are likely to be differences in the population and practice that could affect the incidence. Risk factors should be assessed independently. Complicated cases are at higher risk and their exclusion will give a baseline on which to work.[9]

Two recent studies are summarised in Table 1. Both studies[3 9] commenced in 1984 and were reported in 1991. The relatively high number of intracapsular cataract extractions and the low number of phacoemulsifications probably reflects this fact. However, extracapsular cataract extraction technique is unlikely to have changed a great deal. These two studies represent the most up to date figures on incidence. The average appears to be in the order of 0·1%, but despite this seemingly low level there is no room for complacency and every effort should be made to keep the incidence as low as possible. It is probable that this figure does not include cases of chronic bacterial or fungal postoperative endophthalmitis. Reports of these conditions in the literature comprise either single cases or small series so the effect on the overall incidence should be small.

It has been estimated that over 100 000 extractions are performed in the United Kingdom each year – 92% using the extracapsular technique with the remainder split between intracapsular and other extracapsular techniques.[10] Using these estimates about 126 cases of postoperative endophthalmitis would be expected annually, but of course this figure is speculative and for confirmation a national survey is needed.

What are the causes?

There is increasing recognition that virtually any organism can cause endophthalmitis if introduced in sufficient quantities.[11] DNA studies in *Staphylococcus epidermidis* endophthalmitis suggest that the commonest source of infection is the patient's own flora.[8] Organisms may be carried into the eye as surface fluid refluxes through the wound during surgery.[12]

Additionally, an intraocular lens can become contaminated if it touches the ocular surface and even after exposure to the

Table 1 Incidence of infectious postoperative endophthalmitis

	Cases of endophthalmitis	*Total cataract operations*	*%*
Extracapsular extraction*	236	195 587	0·12
Phacoemulsification*	34	28 474	0·12
Intracapsular extraction*	170	99 971	0·71
Extracapsular extraction†	18	23 622	0·076

*After Javitt *et al*.[9]
†After Kattan *et al*.[3]
(Excludes one phacoemulsification and two complicated cases and comprises 14 culture proved and four culture negative cases.)

Table 2 Bacterial causes of postoperative endophthalmitis

Gram positive	*Gram negative*
Staphylococcus epidermidis	*Proteus* spp
Staphylococcus aureus	*Pseudomonas aeruginosa*
Streptococcus spp	*Haemophilus influenzae*
Propionibacterium acnes	*Klebsiella* spp
Bacillus spp	Most coliform species

atmosphere in the operating theatre.[13] Epidemics have been reported following the use of contaminated irrigating solutions and lens implants.[14]

Table 2 lists the more commonly isolated bacteria in postoperative endophthalmitis. It should be noted that this is not a definitive list as in most series the percentage of cases that are culture negative is high. Gram positive organisms are identified in about 70% of culture proved cases.[15] Studies suggest that *Staphylococcus epidermidis* is the most commonly isolated organism, responsible for about 40% of cases.[3 15 16] *Staphylococcus aureus* is identified in approximately 20% of cases,[3 15] while Gram negative organisms are implicated in 16%.[15] Fungal endophthalmitis is an extremely rare event after cataract extraction although over 20 species have been isolated.[17] Fungal isolates frequently come from one of the families listed in Table 3.

How does it present?

The endophthalmitis following cataract surgery falls into three groups; acute, delayed acute, and chronic. Delayed acute has features similar to acute onset but is usually associated with some complication – for instance, a broken suture[18] or suture removal,[19] an inadvertent filtering bleb,[18] wound dehiscence,[18] or a vitreous wick.[20] Some authors identify the 30th postoperative day as the division between 'early' and 'delayed onset'.[18] While chronic endophthalmitis can present early it is differentiated by its more indolent course.

The development of infection is dependent on the relative virulence of the organism, the size of the inoculum, and the patient's resistance to infection.[21] Additionally, the clinical picture on presentation is related to the delay before treatment is sought. The disease process may have been modified by the use of antibiotics or steroids. Acute endophthalmitis typically presents 2–4 days postoperatively. *Staphylococcus aureus* usually causes a hyperacute picture with a rapid course while the less virulent organisms are associated with a longer delay and a more indolent disease. Fungal endophthalmitis has a greater delay and usually mimics chronic iridocyclitis and vitritis with minimal pain.

Eighty eight per cent of all cases of endophthalmitis occur within 6 weeks of surgery.[22] In the series of 32 cases reported by Heaven *et al*,[23] the mean onset time of the culture positive group was 4 days (range 1–24) while for the culture negative group it was 5 days (range 3–8). Stern *et al*[18] describe early onset endophthalmitis occurring at a mean of 6·4 days (range 1–21) in a mixed postoperative group with the majority presenting within 5 days. These figures compare with those of Kattan *et al*[3] (mean 6 days, range 1–14) where overall 12 of 17 culture proved cases of endophthalmitis after extracapsular extraction occurred in the first 6 postoperative days.

Table 3 Most common fungal species isolated in postoperative endophthalmitis

Aspergillus spp
Cephalosporium spp
Candida spp
Fusarium spp
Voluella spp
Neurospora spp

Table 4 Characteristics of acute and chronic postoperative endophthalmitis

	Acute	*Chronic*
Presentation	2–4 days	>30 days
Symptoms	Ocular pain Reduced vision Headache	Reduced vision Minimal pain
Signs	Lid oedema Conjunctival hyperaemia Chemosis Purulent discharge Corneal oedema Anterior chamber reaction Hypopyon Vitritis Poor red reflex	Bacterial: Steroid responsive iritis Capsular plaque Granulomatous iritis Vitritis Localised vitreous reaction Fungal: Not usually steroid responsive Stringy vitreous reaction

Fox *et al*[19] presented a series of 19 cases of chronic postoperative endophthalmitis in which the onset ranged from 2 days to 8 months with a mean of 8 weeks. However, this may be misleading as the time to diagnosis differs from the time of onset. The time to diagnosis probably reflects the time when infection was suspected and this figure ranges from 1 to 36 months (mean 9·4 months). Localised endophthalmitis is a term used to describe chronic infection where it appears that the organism is sequestered in the capsular bag.[24] The predominant feature is the presence of a white plaque on the capsule associated with chronic inflammation. It has been observed that chronic endophthalmitis can develop after Nd:YAG laser posterior capsulotomy.[1] Features of both acute and chronic infection are presented in Table 4.

How is it managed?

Two main issues have to be addressed – namely, how to identify the infecting organism and how to deliver sufficiently high antibiotic concentrations within the eye. A subsidiary is whether removing infected contents – for instance, aspirating a hypopyon, removing the implant and capsule, or performing a vitrectomy, is valuable as a form of 'incision and drainage'.[25]

Apart from the delayed acute form it can be assumed that the infecting organism gained access at the time of surgery. When intraocular infection is suspected cultures should be taken at the earliest opportunity; however, there is some debate as to the best source of material. There is little to be gained from conjunctival swabs. Initially, provided there is no vitreous communication, the posterior capsule will act as a barrier and infection is probably located within the anterior chamber. Unfortunately, this is not the case for long and in acute endophthalmitis infection rapidly spreads to the vitreous cavity. A number of studies have shown the advantages of vitreous biopsy[15 26] and as it is inappropriate to wait for the result of an anterior chamber tap, both are recommended.

However, Driebe *et al*[15] did have two cases with positive anterior chamber taps and negative vitreous cultures. These cases had intact posterior capsules with posterior chamber lenses. They postulate that under these conditions infection may be limited to the anterior chamber and this seems to be supported by Heaven *et al*.[23] Aspiration within the bag and possibly primary partial capsulectomy are advised[26] in chronic endophthalmitis, particularly if associated with a capsular plaque. A manual irrigation/aspiration system is used to collect aspirate from both the anterior chamber and within the capsular bag.[23]

Simple vitreous aspiration is often unsatisfactory especially if the vitreous is formed. A better alternative is to take a sample of the vitreous core with a suction cutter. The volume aspirated not only serves diagnostic purposes but also creates

space for intraocular injections. When samples are taken using an infusion system they should be passed through a micropore filter as described by Forster[2] or isolated by means of a three way tap. Slides are taken for Gram and fungal staining before immediate inoculation on to a range of aerobic, anaerobic, and fungal culture media. These should include liquid media as they provide a higher yield. A culture is considered positive if there is confluent growth on one or more solid media or growth of the same organism on two or more media, and growth in a liquid medium or scant growth on a solid one is considered equivocal.[2] Anaerobic media should be retained for 14 days if *Propionibacterium acnes* is to be excluded. It is imperative that there is close cooperation between microbiologist and ophthalmic surgeon if the maximum benefit from sampling is to be gained.

Intravitreal antibiotics are generally advised[27] and should be administered after samples have been taken rather than waiting for results. Broad spectrum antibiotics are used that cover the likely infecting organism. Heaven *et al* dispute this recommendation favouring the conventional approach (topical, subconjunctival, and systemic antibiotics) in uncomplicated cataract surgery.[23] However, they admit that the poor outcome following vitreous intervention may have been related more to the severity of the disease than the treatment itself. Topical antibiotics do not reach therapeutic levels within the eye and while periocular injections achieve adequate concentrations in the anterior chamber, the levels are inadequate within the vitreous.[28] The systemic route is of limited value because of the blood-eye barrier. However, there is some evidence that therapeutic levels can be achieved with ciprofloxacin[29,30] and imipenem.[31] Direct injection into the vitreous is the most consistent current method of achieving adequate intraocular levels.[27] It is important to note that the pharmacokinetics of antibiotics differ between phakic, pseudophakic, and vitrectomised eyes.[32]

Great care has to be taken in preparing and administering injections if iatrogenic damage is to be avoided. Protocols for preparation to accurate dilution and volume must be available in the operating theatre. To avoid errors in the administration dose the diluted antibiotic solution should be drawn up into a new syringe which was not used in the preparation of the injection. Gentamicin has been widely used, but is implicated as a cause of macular infarction.[33] Amikacin (0·4 mg in 0·1 ml) is suggested as an alternative combined with vancomycin (1 mg in 0·1 ml).[5] The cephalosporins are also useful with ceftazidime showing promise as an intravitreal agent.[34] Furthermore, probenecid slows the removal of antibiotics that are actively transported from the eye – for example, the cephalosporins, and may be of some benefit.[35] In acute endophthalmitis the use of two agents is recommended to provide the widest possible cover, while vancomycin can be used alone in chronic endophthalmitis.[19] Intraocular injections must be given slowly and into midcavity to avoid retinal damage. They are not an alternative to other treatments but should be given in conjunction with both subconjunctival and topical antibiotics. Subconjunctival vancomycin (25 mg) and ceftazidime (100 mg) together with topical vancomycin and amikacin form part of the regimen adopted by the Endophthalmitis Vitrectomy Study Group.[5]

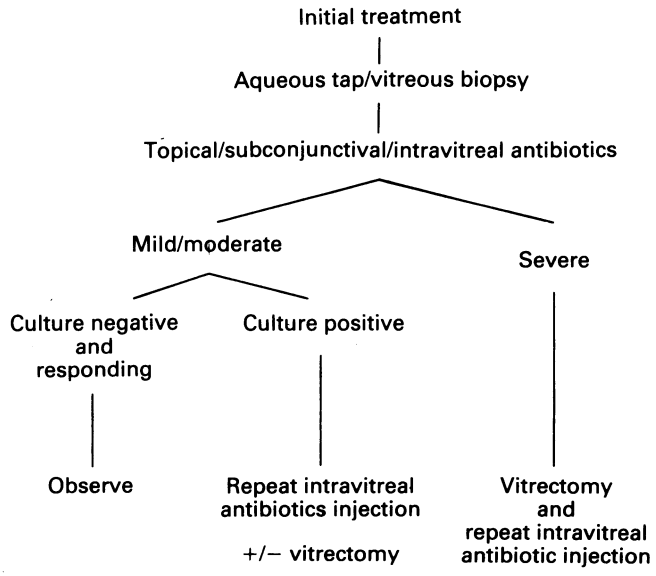

Figure 1 Protocol for the management of postoperative endophthalmitis (adapted from Stern et al[18]).

Care has to be taken when interpreting data on the half life of antibiotics in the vitreous. A variety of factors affect the persistence of antibiotics in the eye – for example, whether the drug is actively secreted as in the case of the cephalosporins or passively lost from the eye as occurs with gentamicin, the presence of the lens or posterior capsule, infection, and whether or not a vitrectomy has been performed. It may not be feasible to extrapolate from animal studies on the half life of antibiotics. Bearing this in mind it is probably safe to repeat intravitreal antibiotics after 48 hours, if no improvement is evident.[2] However, Mandell *et al*[32] have recently demonstrated that the concentration of amikacin is likely to be below therapeutic levels within 24 hours.[32] The choice agent for subsequent injection should be altered in the light of culture results but it is reasonable to repeat with the same agents if these are not available.

The role of vitrectomy in endophthalmitis is controversial and it is hoped that the current multicentre study being conducted in the United States will answer important questions.[5] The dilemma for the clinician is that while animal studies have shown the benefit of vitrectomy and intravitreal injection over injection alone in sterilising the eye[36] the procedure is not a simple one or risk free. Stern *et al*[18] suggest a simple protocol which can be used pending definitive results. Endophthalmitis is categorised into mild to moderate (<15% hypopyon) and severe (>15% hypopyon, no red reflex). The suggested protocol is outlined in Figure 1. Ultrasound scanning has been advocated as a method of assessing vitreous activity and grading severity.[37] Peyman has advocated the use of antibiotics in the infusion fluids during vitrectomy to avoid the need for bolus injection and theoretically reducing the risk of toxicity.[38] In general, the posterior capsule and intraocular lens can be preserved. However, in chronic endophthalmitis associated with *Propionibacterium acnes* if partial capsulectomy removing the plaque proves unsuccessful, a total capsulectomy and lens removal are warranted.[1]

In the rare case of a fungal infection intravitreal amphotericin B (0·005–0·01 mg in 0·1 ml) has been recommended.[2,19] This may be combined with intravitreal miconazole (0·025 mg in 0·1 ml.[2] A sub-Tenon injection of miconazole or amphotericin B is administered together with topical antifungal preparations. To avoid toxicity systemic treatment is avoided but the situation needs to be kept under review and the use of oral imidazoles should be considered.[18]

The last issue that must be dealt with is the use of corticosteroids in combating the destructive effects of the inflammatory reaction on the eye. Steroids have been advocated by all routes (topical, subconjunctival, intravitreal, and systemic) but should be avoided if fungal endophthalmitis is suspected.[2] While Forster[2] recommends subconjunctival triamcinolone 40 mg or dexamethasone 4·0 mg, Diamond[37] suggests dexamethasone 0·4 mg given intravitreally. However, Baum[39] in a comment on the work of Maxwell *et al*[40] notes that there is no evidence regarding the best method of delivering corticosteroids to the eye.

Table 5 Results of treatment in acute endophthalmitis; outcome by infecting organism

Organism	Vision >3/60	Vision <CF	Total
Staphylococcus aureus	7	4	11
Staphylococcus epidermidis	14	4	18
Streptococcus faecalis	2	3	5
Gram negative organisms	4	6	3
Fungal organisms	3	2	5
Culture negative	15	1	16

After Dreibe *et al*[15].
CF=counting fingers.
Minimum 3 months' follow up.
12 of 61 culture positive eyes lost all vision.

What is the outcome?

Many variables affect outcome. Untreated, the prognosis for vision and the integrity of the eye is poor. Outcome relates to the identity of the infecting organism, delay before treatment is started, and the severity or extent of infection. With modern treatment it should be possible to salvage the eye, although the aim must be to preserve visual function. Toxic effects of bacterial products or antibiotics may cause irreparable damage even when the eye has been sterilised. Furthermore, there may be a need for secondary surgery to remove persistent vitreous opacities, treat retinal detachments, or reinsert an intraocular lens. Recurrence of infection or persistent inflammation may also occur.[18 19 23]

Success could be measured by comparing visual results with preinfection vision rather than vision on presentation. Visual rehabilitation after cataract surgery is now so rapid that best postoperative vision should be used as the bench mark. While visual outcome relates to the severity of infection, it is well known that culture negative endophthalmitis has a relatively good prognosis, but endophthalmitis due to *Staphylococcus aureus, Streptococcus pneumoniae*, or Gram negative organisms is poor.[2] Often vitrectomy is reserved for the most serious disease and this may be the reason why presumed benefits of vitrectomy have not been substantiated.[5] Any comparison between therapeutic regimens must include an assessment of severity and a grading system is needed.

The visual outcomes of the series of acute pseudophakic endophthalmitis published by Driebe *et al*[15] and Heaven *et al*[23] are outlined in Tables 5 and 6. In both series *Staphylococcus epidermidis* comprises the most common organism isolated and there is agreement that visual results are second only to the culture negative group. Heaven *et al* document the range of complications from evisceration through presumed antibiotic toxicity to retinal detachment, macular pucker, and oedema. Chronic endophthalmitis has a relatively good prognosis as outlined in Table 7, although relapses may occur.[18]

How can it be prevented?

Despite improvements in treatment, visual outcome after endophthalmitis is often poor and prevention is of utmost importance. If the inoculum is sufficiently large postoperative infection is likely and the aim is to reduce risk factors and minimise entry of organisms during surgery. A lot of recommendations are empiric and suggested as important by various authors. Many seem sensible measures to adopt in reducing postoperative infection.

Table 6 Results of treatment in acute endophthalmitis; outcome by infecting organism

Organism	Vision >3/60	Vision <CF	Total
Staphylococcus aureus	1	1	2
Staphylococcus epidermidis	9	2	11
Streptococcus pneumoniae	nil	2	2
Gram negative organisms	5	nil	5
Culture negative	11	1	12

After Heaven *et al*[23].
CF=counting fingers.

Table 7 Results of treatment in chronic endophthalmitis

Organism	Vision >3/60	Vision <CF	Total
*Propionibacterium acnes**	15	1	16
Culture proved (mixed group)†	16	3	19 (including three fungal cases)

*After Meisler and Mandelbaum.[1]
†After Fox *et al*.[19]
CF=counting fingers.

Detailed preoperative examination is an important step in prevention. This should be directed to exclude cases with infectious blepharitis, and infections of the conjunctiva or nasolacrimal system. Patients with keratoconjunctivitis sicca have a high rate of staphylococcal colonisation.[41] Similarly, it should be noted that individuals with a history of atopic dermatitis have a high carriage rate for *Staphylococcus aureus*.[42] Although we have not found any studies implicating atopy as a risk factor in postoperative endophthalmitis, care should be exercised with these patients. Potential sources of infection elsewhere in the body – for example, leg ulcers, need treatment before elective surgery. Patients with diabetes mellitus form a significant proportion of those undergoing cataract extraction. It is important to be aware that this group is prone to infection and is at higher risk of postoperative endophthalmitis.[3]

Genetic analysis studies in *Staphylococcus epidermidis* proved endophthalmitis[8] suggest that in the majority of these cases the causative organisms originate from the patient's own lid flora. Despite this evidence it is accepted that routine preoperative conjunctival swabs do not have a role in preoperative preparation.[11] Culture positive eyes are commonplace[43–46] and yet only a small proportion go on to develop endophthalmitis. The list of potential pathogens grows ever larger and it is difficult to decide on risk from the results of swabs. There appears to be variability in the isolation of potential pathogens using daily swabs such that *Staphylococcus aureus* was isolated from over 20% of lid margin samples despite previously negative cultures.[47] The act of taking a swab may of itself modify lid flora.

The argument for the use of prophylactic perioperative antibiotics is far from conclusive and while it seems logical to attempt reduction of the bacterial load a corresponding reduction in the rate of endophthalmitis in modern practice has not been proved. Topical antibiotics are effective in reducing the periocular flora[48] and in this respect it has been suggested that gentamicin is more effective than chloramphenicol. Topical ofloxacin has a similar spectrum to gentamicin although its effectiveness on normal flora has not been investigated in vivo.[49] While most studies investigating the role of topical antibiotics are flawed the balance probably lies in favour of their ability to reduce the postoperative endophthalmitis rate.[11]

Subconjunctival antibiotics may be given before or at the end of surgery. Therapeutic levels are achieved in the anterior chamber and in theory this should prevent infection.[28] Rabbit studies have given some support to this theory[50] but this has not been demonstrated in humans. Perlman[51] showed the effectiveness of subconjunctival antibiotics but the study was small and uncontrolled, while in another study Kolker *et al*[52] demonstrated that this route was better than no prophylaxis at all. Claims that infection may be delayed rather than prevented[53] have not been confirmed. There is no evidence for

the superiority of combined topical and subconjunctival antibiotics over topical alone. However, there have been case reports of macular infarction after routine uncomplicated subconjunctival aminoglycoside injection following cataract extraction.[33 54]

Recently, interest has been growing regarding the use of antibiotics in the irrigating solutions. To our knowledge no formal clinical trials have been published in relation to cataract surgery although a reduced infection rate has been claimed in correspondence.[7] This technique has been advocated for routine vitreoretinal surgery. Maxwell and Diamond[55] describe a series of 6000 elective procedures using 2 mg gentamicin per 500 ml of balanced salt solution without a single case of infection.

Povidone iodine solution (5%) has been shown to significantly reduce conjunctival and perilimbal flora.[45 56–58] The solution has not only broad antibacterial activity but is also effective against fungi and several viruses. Positive culture rates from the conjunctiva of normal eyes have been reduced from 60% or more to 9·6%[56] and 17%[45 58] using a combined regimen of topical antibiotics and irrigation with povidone iodine solution. The use of povidone iodine has been shown to reduce the endophthalmitis rate,[8] but it should be stressed that the solution must remain in contact with the eye for several minutes. The ocular surface should be irrigated with saline before surgery as it has been suggested that endothelial toxicity may occur if significant amounts enter the eye.

The importance of a 'no touch' technique during surgery with the minimum amount of surgical manipulation and instrumentation are logical steps in the prevention of infection. Adhesive drapes which exclude the lashes and lid margins should be used but there is no evidence supporting the cutting of lashes and in any case potential pathogens reside on the lid surface and in lash roots. Irrigating solutions should not be allowed to pool in the conjunctival fornix as reflux may carry bacteria into the eye.[12]

Accurate wound closure is considered to be of great importance. Driebe *et al*[15] in their retrospective analysis of 83 cases of pseudophakic endophthalmitis noted wound abnormalities in 22% at the time of diagnosis. These included vitreous wicks, visible wound leaks, wound ruptures or dehiscence, and inadvertent filtering blebs. They considered this a highly significant finding and felt that these defects contributed to the onset of infection. Speculation has arisen regarding sutureless surgery and endophthalmitis; however, in the absence of controlled studies the risk remains unproved.[59] Certainly suture removal is implicated and every attempt should be made to avoid pulling the exposed end of a broken suture through the cornea. The anterior chamber seems to have a greater ability to resist infection than the vitreous and an intact posterior capsule is thought to be a protective barrier which hinders spread of infection from the anterior chamber.[60 61] Vitreous loss is associated with a higher rate of endophthalmitis.[9 15] This can be attributed not only to posterior communication but also increased operating time and surgical manipulation.

Intraocular lenses with polypropylene haptics have been implicated as a risk factor.[62] Polypropylene may have higher surface adhesion for bacteria than polymethyl methacrylate (PMMA).[63] The implications of this are far reaching and need to be confirmed in further studies. At the end of surgery it is traditional to apply a pad although there is no real logic for this.[64] Although Laws *et al* were unable to demonstrate increased bacterial proliferation with the use of a pad, they comment that a shield alone seem to be safe and should suffice.[65]

Conclusion

For most ophthalmologists cataract surgery forms the bulk of the surgical workload and endophthalmitis is an ever present risk. However, the incidence is so low that no individual will be able to prove independently the effectiveness or otherwise of a particular preventive measure or treatment regimen. Clinical trials will require the cooperation of multiple centres to achieve suitable numbers, but it is doubtful if all the possible variables could be accounted for.

It is not possible to give unequivocal advice on preventive measures as most are empiric and seem reasonable precautions. Preoperative examination to exclude infection, preparation with povidone iodine, occlusive draping techniques, and meticulous theatre techniques appear sensible. The administration of perioperative antibiotics is justified, although studies are required to test the efficacy of novel methods such as the incorporation of antibiotics in the infusion fluid or even direct injection into the capsular bag. The choice of antibiotic also needs to be addressed, particularly in the light of complications associated with aminoglycosides and the advent of new broad spectrum agents.

It is probably not possible to isolate all the variables peculiar to cataract surgery and control for them in studies. However, careful surgery with attention to detail in an attempt to avoid complications and particular attention to wound closure seem obvious. The role of intraocular implants in postoperative endophthalmitis needs further study with regard to composition and surface modification.

When faced with postoperative inflammation a high index of suspicion is required. Vitreous biopsy and anterior chamber tap are essential with capsular biopsy if indicated by the presence of a plaque. Close cooperation with a microbiologist is important if the most is to be made of the samples taken. Until the value of vitrectomy is proved beyond doubt its use will depend in part on access to an experienced vitreous surgeon and so to the availability of resources. The Endophthalmitis Vitrectomy Study is attempting to provide answers on the effectiveness of vitrectomy with or without intravenous antibiotics and the results of this study are eagerly awaited. To allow for comparison of treatment regimens and outcomes some attempt should be made to standardise the assessment of the infected eye.

With the current emphasis on audit there should be a method of reporting serious infection. As numbers are small it would probably be best to do this on a national basis. Surgeons often feel responsible and may fear litigation, so care must be taken to ensure anonymity if underreporting is to be avoided. Such a reporting system would serve as the first step in identifying factors for further prospective studies.

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