Case Series

Endophthalmitis after strabismus surgery: incidence and outcome in relation to age, operated eye muscle, surgical technique, scleral perforation and immune state


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Purpose: Identify risk factors for endophthalmitis after strabismus surgery (EASS) and relate these to incidence and outcome.

Methods: Ophthalmologists, who had operated, diagnosed or treated EASS, completed a case record form with 71 questions in six domains: Preoperative, Surgery, Perforation, Postoperative, Outcome and Experts’ opinion. To estimate the age-specific incidence per number of strabismus operations in the Netherlands during 1994-2013, the age distribution of Dutch cases was compared with the age-specific rates of strabismus surgery in the Dutch Registry of Strabismus Operations and with population data. Exploratory data analysis was performed. The immune state was evaluated in six patients. Five enucleated eyes were studied histopathologically.

Results: None of the 26 patients (27 eyes with EASS) were between 9 and 65 years old, except for one patient with retinal haemorrhage followed by endophthalmitis. In the Netherlands during 1994-2013, the rate of EASS was approximately one per 11 000 strabismus operations, but one per 4300 for children aged 0–3 and one per 1000 for patients 65 and older. Endophthalmitis was diagnosed on postoperative day 1–4 in children aged 0–3. In all 15 children aged 0–5, the 16 affected eyes were phthisical, eviscerated or enucleated. The involved eye muscle had been recessed in 25 of 27 cases. It was a medial rectus in 15 of 16 children aged 0–6. It was a lateral (6), inferior (2) or medial (1) rectus in elderly. Scleral perforation went unnoticed in all children (no record in three) and in two of seven elderly (no record in two). Histopathology showed transscleral scarring compatible with scleral perforation in four patients but, in a two-year-old girl who had EASS together with a transient medial rectus palsy, the sclera underneath the former suture tract was not perforated but did contain the long posterior ciliary artery. Conclusions: Endophthalmitis after strabismus surgery (EASS) affects children and elderly, with a grave outcome in young children. It occurs after recession of the medial rectus muscle in children, and it may occur without scleral perforation. Age and perforation are key determinants that interact with other factors that determine the occurrence and fulminance of EASS.

Key words: endophthalmitis – strabismus surgery – surgical contamination – antisepsis – complication – enucleation – scleral perforation – bacterial carrier state – immune deficiency
Introduction

Medical action is and will always be associated with a certain risk. This also applies to strabismus surgery. One should not be misled by the fact that grave complications after strabismus surgery are, fortunately, very rare and one should not refer to strabismus operations as being almost risk-free. As Knobloch & Lorenz (1962) and others have aptly noted, grave complications after strabismus surgery are more common than appears from the literature because, for obvious reasons, failures are rarely published. Knobloch & Lorenz sent a questionnaire to 1150 ophthalmic surgeons and got 324 responses, covering an estimated 300 000 strabismus operations. Of the 193 serious complications reported, endophthalmitis after strabismus surgery (EASS) accounted for 87, death from anaesthesia for 60, scleral necrosis for 32, retinal detachment for 8, retrobulbar haematoma for 4 and sympathetic ophthalmia for 2. Two cases of bilateral EASS and two with sympathetic ophthalmia led to bilateral blindness. Unilateral blindness resulted from 68 cases of EASS, 8 cases of retinal detachment and 4 cases of retrobulbar haematoma.

Thirty years later, Simon et al. (1992) sent a questionnaire to 342 ophthalmic surgeons, 223 of whom responded. Scleral perforations with known retinal damage occurred in 728 of nearly 554 000 eye muscle procedures performed by 223 surgeons. Fourteen retinal detachments and only three cases of EASS were reported. Nine patients sustained visual loss. In a surveillance study twenty years later, Bradbury & Taylor (2013) received 60 reports of adverse events and complications in a period during which approximately 24 000 strabismus operations were performed in the United Kingdom. There was a single reported case of EASS in a child and one report of retinal detachment in an adult, suggesting that EASS is an exceedingly rare condition. However, in a similar surveillance study on endophthalmitis following cataract surgery by Kamalarajah et al. (2004), under-reporting was estimated by independently contacting units with databases of vitreous cultures. The corrected incidence was almost twice as high as the incidence of endophthalmitis estimated with the collected reports. Under-reporting of EASS may be more likely than after cataract surgery, because of the large discrepancy between the burden of strabismus and that of loss of an eye, especially in young children, and because of concern for litigation that may follow.

It is generally assumed that EASS only occurs after the sclera has been perforated by a needle.

First, how frequently do perforations occur? In prospective studies that employed postoperative funduscopv microscopy in consecutive strabismus operations, Morris et al. (1990) found one case of perforation (sclera and retina) in 67 patients (100 eyes), Noel et al. (1997) found 3 perforations and 14 funduscopic abnormalities without retinal perforation in 765 children (1129 recessions and 349 resections), Dang et al. (2004) found 6 perforations (sclera and retina) and 11 scleral penetrations without retinal perforation in 144 patients (217 eyes), Kalluzny et al. (1977) found 11 scleral penetrations with or without retinal perforation in 108 eyes, Taherian et al. (2004) found 10 perforations in 700 eyes (1121 muscles) and Surachatkumonekul et al. (2009) found 15 perforations in 1095 patients (2195 muscles). In conclusion, perforations are two orders of magnitude more frequent than EASS. What other conditions must be met for EASS to develop? Is contamination of the needle or suture a rare event that could explain the rare occurrence of endophthalmitis after scleral perforation?

On the contrary, Olitsky et al. (1998) and Carothers et al. (2003) found between 16% and 25% of needles or sutures to be contaminated after strabismus surgery. Rogers et al. (2011) found between 30% and 34% contaminated sutures or needles after strabismus surgery, with or without extra scrubbing of the eyelashes with 5% povidone–iodine. Saber Moghaddam et al. (2011) found a close similarity between the bacteriae cultured from the fornix before povidone–iodine antisepsis and those cultured from contaminated needles or sutures after strabismus surgery.

Conversely, is a scleral perforation a prerequisite for EASS to develop? In a series of six children (median age 2 years) with endophthalmitis and blindness after strabismus surgery, Recchia et al. (2000) found no anatomical changes of the sclera or the retina that were suggestive of a perforation, in histopathological examination of the enucleated eyes of two of the children.

In the current series of 26 patients (27 eyes) with EASS, the authors, most of whom were the operating ophthalmologists of the patients, conjoined their experiences and could thereby study its incidence and outcome in relation to the age of the patient, to the kind of eye muscle that was operated, to the surgical technique that was used and to whether scleral perforation had occurred.

Methods

EASS occurred in a two-year-old girl at the Erasmus Medical Center Rotterdam in February 2005. Thereafter, a Case Record Form with 71 questions in 6 domains was developed (Table 1) and sent to ophthalmologists who had operated, diagnosed or treated a case of EASS, and to ophthalmic pathologists who had evaluated a specimen for histopathological diagnosis.

Case record form

First, we made an inventory of all potential risk factors for EASS. Presumed risk factors were categorized in five domains according to the phase of the disease, applying to situations and circumstances before, during and after surgery. At a meeting of paediatric ophthalmologists, vitreoretinal surgeons and orthoptists devoted to EASS in Rotterdam in May 2006, several cases were discussed in detail and the evidence for and against many of the presumed risk factors was discussed. Questions were subsequently formulated for the Case Record Form within each domain: Preoperative, Surgery, Scleral perforation, Postoperative, Treatment and Outcome, Experts’ opinion (Table 1).

Inclusion

From 2005 onwards, we contacted paediatric ophthalmologists and asked whether they had seen similar patients. First, the strabismus surgeons at all university clinics in the Netherlands and Belgium were contacted. As most operations for strabismus are performed by general ophthalmologists in...
Table 1. Endophthalmitis After Strabismus Operation Questionnaire

Preoperative: History and diagnosis
1. What was the date of birth of your patient and what the date of surgery (if unknown supply age)?
2. What were the orthoptic diagnoses?
3. What was the best corrected preoperative visual acuity?
4. What was the spherical equivalent?
5. Did the patient have complaints, other than cosmetic?
6. The eye where endophthalmitis occurred was the right or left eye?
7. Peculiarities in the history of the patient? Had the patient recurring airway infections, recent airway infections, pre or dysmaturity, immunologic deficiency, allergy, asthma, diabetes mellitus?
8. Was the patient vaccinated for H. Influenzae group B?
9. Was the patient in the month preceding surgery healthy? If not specify.
10. Did the patient take any medication?
11. Did influenza, colds or airway infections occur in an epidemic fashion in the period that surgery was performed?
12. How often do you see minor postoperative infection in strabismus patients with concurrent airway infection?
13. In what month and weekday did surgery take place? Daycare or admission? Local or general anaesthesia?
14. Was it a reoperation of the affected eye?
15. How many operations did this eye have before, for strabismus, for cataract or else?
16. In case of strabismus surgery, which muscles had been previously operated on the affected eye?
17. What strabismus operation was performed now?

Surgery: Disinfection, kind of operation, instruments and events
18. Who performed the strabismus operation?
Could you indicate how many strabismus operations he or she performed yearly, for how many years?
19. Who assisted during this operation?
20. In case of a resident operating, who was involved in operating the affected muscle?
21. What was, most likely, used for antisepsis, povidone-iodine or else? What concentration was used?
22. Was the disinfectant past expiration date or was it used long after opening? What did you disinfect?
In case the fornix was disinfected, how? Were both eyes disinfected before draping?
Was disinfection repeated for the second eye after the first eye had been operated?
23. What suture and needle was used?
24. Have you had problems with surgical instruments for strabismus surgery or their sterilization?
Has anything happened during this or other strabismus operations that may have influenced sterility?

Perforation
25. Have you ever noticed that scleral perforation occurred during strabismus surgery?
26. How did you notice scleral perforation in such a case?
27. Has a scleral perforation been noticed during the operation with the complication?
Has a scleral perforation or retinal bleeding been noticed by funduscopy? Did you notice loss of vitreous?
28. In case of perforation, what was its subsequent treatment: with antibiotics, by cryocoagulation?
29. If a scleral perforation was not noticed, how sure are you that none occurred?
30. If a scleral perforation was noticed, was funduscopy performed after or at the end of surgery?
31. Did you notice any peculiarities during surgery?
32. On what postoperative day does funduscopy routinely take place after strabismus surgery?
33. Did you ever notice a scleral perforation with funduscopy that had not been suspected during surgery? How often?

the Netherlands, we also contacted ophthalmologists in most regional hospitals where strabismus surgery is performed, directly or indirectly. A similar procedure was attempted in Belgium, Germany and the UK. Calls to contribute cases were done at international meetings and in the newsgroup of the American Association for Pediatric Ophthalmology and Strabismus.

Patients were included when their strabismus had been operated or their EASS had been diagnosed, treated or evaluated by the participating ophthalmologist, orthoptist or ophthalmic pathologist. Patients in whom retinal haemorrhage had preceded EASS were included but analysed separately. The Case Record Form was filled out by the participating ophthalmologist, orthoptist or ophthalmic pathologist.

Age-specific rate of EASS per number of strabismus operations (exploratory data analysis)
We found comparatively high rates of EASS in children and in elderly patients, with no cases occurring between the ages of 9 and 65, apart from a 14-year-old girl who had a retinal haemorrhage after a myopexy of the medial rectus as the primary event. Strabismus surgery is carried out more frequently in children. Therefore, the age-specific incidence of EASS had to be related to the age-specific incidence rate of strabismus operations. To estimate these, on the one hand a well-defined population was needed with most of the cases of EASS identified over a long period of time. On the other hand, a good estimate of the age-specific incidence rate of strabismus operations in that population was needed over that same period of time. Seven cases of EASS had been identified in the Netherlands over the 20-year period 1994–2013. In reality, more cases, adults in particular, may have occurred during that period. It seems unlikely, however, that more children were affected in that period, because information about such patients would have popped up in the numerous discussions we had in the Netherlands in many meetings devoted to the subject and at congresses with presentations on the subject, between 2005 and 2013.

To calculate the age-specific incidence rate of strabismus operations in the Netherlands over 1994–2013, data were combined from the Dutch Registry for Strabismus Operations (consulted 25 March 2015), from incidence studies of strabismus operations in the United Kingdom and Canada, and from demographic population data.

First, the age distribution was determined of 7679 strabismus operations registered in the Dutch Registry for Strabismus Operations over an 8-year period from 2007 to 2014. This registry, aimed at monitoring quality of care, is open for ophthalmologists in the Netherlands, to compare their results of strabismus surgery with the average results of strabismus surgery in the
To estimate what fraction of the strabismus operations in the Netherlands had been registered in the Dutch Registry for Strabismus Operations in the 8-year period from 2007 and 2014, we compared the annual incidence of strabismus operations per age group found by Arora et al. (2005) for Scotland (age 0–14: 8.8), for England and Wales (age 0–14: 7.8) and for Ontario (age 0–14: 7.2; age 0–16: 6.6) in 2000, and those found by Heng et al. (2013) in 2010 for Scotland (age 0–15: 7.5), for Wales (age 0–14: 5.7) and for England (age 0–14: 6.4), with the annual incidence of strabismus operations registered in the Dutch Registry for Strabismus Operations for similar age groups: For age 0–14 this was given as: 1.83, for age 0–15: 1.75, and for age 0–16: 1.69. Accordingly, the annual incidences of strabismus operations in the Netherlands that are registered in the Dutch Registry for Strabismus Operations were approximately a fourth of those found in the United Kingdom and Canada.

The incidence rate of strabismus operations in the Netherlands is not likely to be very much different from those in Scotland, England, Wales and Ontario and, therefore, we assumed that approximately one fourth of the strabismus operations had been registered during the 8-year period from 2007 to 2014. Accordingly, we multiplied the incidence rates of age-specific, strabismus operations registered in the Dutch Registry for Strabismus Operations by four to estimate the overall age-specific incidence rates of strabismus operations in the Netherlands. Finally, these rates were multiplied by the age composition of the population in the Netherlands in the 20 years from 1994 to 2013 (CBS Statistics Netherlands, 2015) to estimate the age-specific number of strabismus operations in the Netherlands over the 20-year period from 1994 to 2013, during which seven cases of EASS had occurred in the Netherlands, three in small children and four in elderly.

Bacterial species, histopathology and immune state

The results of Gram stains, vitreous cultures and conjunctival cultures were analysed. Patients 5, 6, 8, 10, 19 and 22 were invited to the Sophia Children’s Hospital at the Erasmus Medical Center Rotterdam for assessment of their immune state. After a physical examination, antibodies against S. pneumoniae capsular polysaccharides and other immunological parameters were assessed in blood samples.

Enucleated eyes of cases 5, 6, 8, 11 and 18 were studied histopathologically. In patients, 5 and 8 additional sections were made of the original histopathological specimens, to identify or exclude scleral perforations.

Table 1 (Continued)

<table>
<thead>
<tr>
<th>Postoperative: Medication, signs, symptoms and microbiological culture</th>
</tr>
</thead>
<tbody>
<tr>
<td>34. What postoperative treatment was prescribed?</td>
</tr>
<tr>
<td>35. Was the eye patch used in the 24 hr after surgery?</td>
</tr>
<tr>
<td>36. How was the eye patch used?</td>
</tr>
<tr>
<td>37. Was the eye patch used the entire day or just at night?</td>
</tr>
<tr>
<td>38. Did the relatives indicate difficulty administering eye drops or do you suspect such difficulty?</td>
</tr>
<tr>
<td>39. Were you under the impression that the patient (adult) had taken his or her eye drops as prescribed?</td>
</tr>
<tr>
<td>40. Who first noticed symptoms that pointed towards endophthalmitis or retinal detachment?</td>
</tr>
<tr>
<td>41. Date of first postoperative examination. What were the symptoms?</td>
</tr>
<tr>
<td>42. What were the signs? Was eye motility limited more than could be expected from the surgery itself?</td>
</tr>
<tr>
<td>43. Was the patient examined by an orthoptist, an ophthalmologist or a resident?</td>
</tr>
<tr>
<td>44. Date that the diagnosis of endophthalmitis was made. What were the symptoms?</td>
</tr>
<tr>
<td>45. What were the signs?</td>
</tr>
<tr>
<td>46. Was the patient examined by an orthoptist, an ophthalmologist or a resident?</td>
</tr>
<tr>
<td>47. Was it possible to take a vitreous tap for culture at the time? Has a vitreous tap been taken for culture?</td>
</tr>
<tr>
<td>48. Was Gram staining performed and what was the result?</td>
</tr>
<tr>
<td>49. What bacteria were cultured? Were Gram and culture results communicated to the ophthalmologist immediately?</td>
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<tr>
<td>50. Were antibiotics administered intravitreally? Were steroids administered intravitreally?</td>
</tr>
<tr>
<td>51. Were antibiotics administered by a different route?</td>
</tr>
<tr>
<td>52. Has other medication been administered?</td>
</tr>
<tr>
<td>53. Did a cyclitic membrane develop? How many days postoperatively did miosis start?</td>
</tr>
<tr>
<td>54. What surgery or other measure was then carried out?</td>
</tr>
<tr>
<td>55. Did complications result from these operations or from other measures?</td>
</tr>
<tr>
<td>56. When was the last examination?</td>
</tr>
<tr>
<td>57. What was the visual acuity at that point?</td>
</tr>
<tr>
<td>58. Had phthisis occurred?</td>
</tr>
<tr>
<td>59. What was the visual acuity at the last examination?</td>
</tr>
<tr>
<td>60. In the Netherlands, strabismus patients are often first examined postoperatively by an orthoptist only. Do you now think all first postoperative exams should include an ophthalmological examination?</td>
</tr>
<tr>
<td>61. What were the signs?</td>
</tr>
<tr>
<td>62. How was the eye patched?</td>
</tr>
<tr>
<td>63. Have you become more reluctant to let residents operate?</td>
</tr>
<tr>
<td>64. Can the choice who operates, ophthalmologist or resident, be influenced by the patient or by the child’s parents?</td>
</tr>
<tr>
<td>65. Have you become more reluctant to operate on the better eye in case of amblyopia?</td>
</tr>
<tr>
<td>66. Do you agree to: ‘A perforation cannot occur if you can see the point of the needle at all times?’</td>
</tr>
<tr>
<td>67. Do you agree to: ‘An endophthalmitis can only occur after a perforation?’</td>
</tr>
<tr>
<td>68. How should, in your opinion, information about the operation be given to patients and their parents?</td>
</tr>
<tr>
<td>69. Who should, in your opinion, give this information?</td>
</tr>
<tr>
<td>70. Did you extend the information given to patients and their parents after the complication occurred?</td>
</tr>
</tbody>
</table>

Netherlands. It was started in 2007 and is not mandatory yet, but increasing numbers of ophthalmologists register their strabismus operations in the registry. The 7679 age-specific, registered strabismus operations were compared with the age composition of the population in the Netherlands from 2007 to 2014 (consulted 25 March 2015) to find the age-specific incidence rate of registered strabismus operations.
Results

Twenty-three ophthalmologists and one orthoptist from the United States, Mexico, Canada, Australia, Italy, Israel, Germany, Belgium and the Netherlands reported on 26 patients (27 eyes). The data compiled from the Case Record Forms of the patients are summarized in Table 2.

All but one of the treating and operating ophthalmologists and one treating orthoptist are co-authors. In none of the 26 cases, legal action had been taken, but in three cases complaints have been submitted.

Data about cases of EASS were collected from 2005 to 2018. The information was gathered directly by the surgeon from the patient’s record in all cases except in cases 9 and 12 where the patient’s paper record was no longer available. The ophthalmologist remembered the essential findings in these patients in detail, however. Case 18 was reported by the ophthalmologist who examined the enucleated eye histopathologically. Case 11 was reported by an ophthalmologist after review of the ophthalmic pathological records and has been published previously (Huang et al. 2011).

Patients 17 and 21, who were 14 and 66 years old, had a retinal haemorrhage after a perforation as primary event and developed vitreous haemorrhage, retinal detachment and endophthalmitis later. In case 17, myopexy of the medial rectus muscle caused a retinal haemorrhage. After subsequent removal of the suture a vitreous haemorrhage occurred and retinal detachment and endophthalmitis developed. In case 21, cryotherapy was performed after scleral perforation, but a vitreous haemorrhage developed the following day which was treated by vitrectomy on the third postoperative day.

Age-specific rate of EASS per number of strabismus operations (exploratory data analysis)

The ages of the remaining 24 (25 eyes) patients with EASS as primary event were either 9 years or younger, or 65 years or older (Fig. 1). The age-specific incidence rates of strabismus operations in the Netherlands in the 20-year period from 1994 to 2013 were estimated as described in the Methods section. Both the age-specific number of strabismus operations in the Netherlands and the seven cases that occurred in the 20-year period from 1994 to 2013 are shown in Fig. 1, together with the other 19 patients (20 eyes) that occurred in the Netherlands before 1994 or occurred outside the Netherlands.

The overall rate of EASS in the 20-year period 1994–2013 in the Netherlands was estimated at 1:10 968 strabismus operations. It was higher for young and for old age groups, however. On the basis of the observed three young children with EASS in the Netherlands during 1994–2013, it was estimated at 1:3141 for age 0–2 and 1:6439 for age 0–4. On the basis of the observed four elderly with EASS in the Netherlands during 1994–2013, it was estimated at 1:959 for 65 years and older (Table 3).

Clinical data from case record forms

The data collected from the Case Record Forms are summarized below for each domain: Preoperative, Surgery, Scleral perforation, Postoperative, Treatment and Outcome, Experts’ opinion. Items that are relevant for presumed risk factors for EASS are worked out in some detail.

Pivotal items have been listed in Table 2 for quick comparison.

Domain surgery

Fourteen of the 17 strabismus operations in children and 3 of the 9 strabismus operations in the elderly patients were bilateral. Patient 13 had had a circumcision with strabismus surgery in the same session of surgery. Case 2 had bilateral EASS. The involved eye muscle – the operation of which caused the endophthalmitis – was recessed in 25 out of 27 cases. A myopexy and a resection of the involved muscle were done in the other two.

In 15 of 17 children, the involved eye muscle was a medial rectus. A lateral rectus re-resection caused endophthalmitis in patient 4 aged 1 who had had previous medial rectus recessions and previous lateral rectus resections. A lateral rectus recession caused endophthalmitis in patient 16 aged 9.

Among 9 elderly patients, surgery on the lateral rectus caused endophthalmitis in 6 cases, on the inferior rectus in 2 cases and on the medial rectus in 1 case. A hang-back recession was done in case 25. Among the elderly patients, the affected eye had been operated on previously in 6 out of 9 cases. Most operations were performed under general anaesthesia, patients 21 and 26 were operated in local anaesthesia; in case 18, this was unknown. Six out of 21 patients were operated on a Friday.

For preoperative antisepsis, povidone–iodine was used in 15 out of 16 cases and cetrimide in one case. In 5 cases 10% povidone–iodine solution was used, in three cases 1%, in four cases 5% and in the remaining cases this was unknown. The conjunctival fornices were rinsed in 6 cases. In cases of bilateral surgery, disinfection was repeated before operating the second eye in 2 out of 15 cases. Few surgeons had paid attention to the expiration date of the povidone–iodine solution, whether it had been diluted or not to 1%, for instance, or to the date of opening of the bottle.
Table 2. Summarized data of the 26 patients (27 cases) with EASS

<table>
<thead>
<tr>
<th>No</th>
<th>Age</th>
<th>Year</th>
<th>Comorbidity &amp; previous surgery affected eye</th>
<th>Diagnosis</th>
<th>Acuity affected eye</th>
<th>Acuity unaffected eye</th>
<th>Se aff eye</th>
<th>Se unaff</th>
<th>Involved rectus</th>
<th>Operation</th>
<th>Performed</th>
<th>Primary diagnosis</th>
<th>Diagn at anterior chamber</th>
<th>Culture</th>
<th>Subsequent findings</th>
<th>Vitrectomy</th>
<th>Subsequent surgery</th>
<th>Last known state</th>
<th>Period postop</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.9</td>
<td>2011</td>
<td>siblings with respiratory illness at time of surgery</td>
<td>esotropia</td>
<td>fractured and followed</td>
<td>fractured and followed</td>
<td>+6</td>
<td>+6</td>
<td>medial recession</td>
<td>no</td>
<td>endophthalmitis</td>
<td>day 2: hypopyon</td>
<td>pneumococ</td>
<td>day 2: cult &amp; AB, day 6: vitrectomy with lenssect &amp; silic oil</td>
<td>phthisis</td>
<td>1 month</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2a</td>
<td>2004</td>
<td>none known</td>
<td>R medial recession</td>
<td>esotropia</td>
<td>R medial recession</td>
<td>no</td>
<td>endophthalmitis</td>
<td>day 2</td>
<td>hypopyon, eyelid edema</td>
<td>day 2: hypopyon, pseudom aer</td>
<td>day 2: fever, LE day 3: vitrect</td>
<td>LP</td>
<td>14 years</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2b</td>
<td>2004</td>
<td>none known</td>
<td>L medial recession</td>
<td>esotropia</td>
<td>L medial recession</td>
<td>no</td>
<td>endophthalmitis</td>
<td>day 2</td>
<td>hypopyon, pseudom aer</td>
<td>day 2: hypopyon, eyelid edema</td>
<td>day 2: fever, LE day 3: vitrect</td>
<td>NLP</td>
<td>14 years</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>1.5</td>
<td>2011</td>
<td>brother with influenza at time of surgery</td>
<td>esotropia</td>
<td>fractured and followed</td>
<td>fractured and followed</td>
<td>+1.5</td>
<td>+1.5</td>
<td>medial recession</td>
<td>no</td>
<td>endophthalmitis</td>
<td>day 3: hypopyon, H influenzae</td>
<td>day 5: vitrectomy</td>
<td>phthisis</td>
<td>3 months</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>1.7</td>
<td>2009</td>
<td>residual eso &amp; lat r recession, prematurity, asthma from age 7 months, exema as baby</td>
<td>residual eso &amp; lat r recession, prematurity, asthma from age 7 months, exema as baby</td>
<td>central steady maintained fix</td>
<td>central steady maintained fix</td>
<td>+2</td>
<td>+2</td>
<td>lateral re-resection</td>
<td>no</td>
<td>endophthalmitis</td>
<td>day 4: plasmoid, pneumococ</td>
<td>day 4: vitrectomy with lenssectomy</td>
<td>LP, small eye</td>
<td>2 years</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>1.7</td>
<td>1994</td>
<td>prematurity, asthma from age 7 months, exema as baby</td>
<td>esotropia</td>
<td>fractured and followed</td>
<td>fractured and followed</td>
<td>medial recession</td>
<td>no</td>
<td>endophthalmitis</td>
<td>day 2</td>
<td>fibrin</td>
<td>day 7: sinusitis, day 10: cornea ulcer, lens opacity</td>
<td>day 55: vitrectomy</td>
<td>enucleation</td>
<td>4 months</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>2.4</td>
<td>2005</td>
<td>recurrent resp inf; lacr duct obstruct, NVI palsy 3 months preop; cold week preop</td>
<td>esotropia</td>
<td>central steady maintained fix</td>
<td>central steady maintained fix</td>
<td>+1</td>
<td>+1</td>
<td>medial recession</td>
<td>no</td>
<td>endophthalmitis</td>
<td>day 2: hypopyon, H influenzae</td>
<td>day 28: vitrectomy with lenssectomy &amp; silicone oil</td>
<td>enucleation</td>
<td>14 years</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>2.7</td>
<td>2007</td>
<td>prematurity</td>
<td>esotropia</td>
<td>0.8</td>
<td>1.0</td>
<td>+1.25</td>
<td>+1.25</td>
<td>medial recession</td>
<td>no</td>
<td>endophthalmitis</td>
<td>day 3</td>
<td>hypopyon</td>
<td>day 8: cyst &amp; staph</td>
<td>day 15: umbilical cord &amp; lenssectomy</td>
<td>enucleation</td>
<td>day 15</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>3.1</td>
<td>2004</td>
<td>none known</td>
<td>esotropia</td>
<td>0.75</td>
<td>0.75</td>
<td>+5</td>
<td>+5</td>
<td>medial recession</td>
<td>no</td>
<td>endophthalmitis</td>
<td>day 1</td>
<td>hypopyon</td>
<td>day 9: vitrectomy with lenssectomy</td>
<td>day 28: enucleation</td>
<td>enucleation</td>
<td>9 months</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>3.5</td>
<td>1970</td>
<td>prematurity, psychomotoric retardation</td>
<td>esotropia</td>
<td>good</td>
<td>good</td>
<td>medial recession</td>
<td>no</td>
<td>endophthalmitis</td>
<td>day 3</td>
<td>hypopyon</td>
<td>day 9: vitrectomy with lenssectomy</td>
<td>day 15: enucleation</td>
<td>phthisis</td>
<td>6 months</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>4.1</td>
<td>1999</td>
<td>prematurity, psychomotoric retardation</td>
<td>esotropia</td>
<td>1.0</td>
<td>1.0</td>
<td>+1.25</td>
<td>+1.75</td>
<td>medial recession</td>
<td>no</td>
<td>endophthalmitis</td>
<td>day 2</td>
<td>hypopyon</td>
<td>day 7: cyst &amp; staph</td>
<td>day 17: vitrect with silic oil</td>
<td>phthisis</td>
<td>6 years</td>
<td></td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>4.5</td>
<td>1959</td>
<td>esotropia</td>
<td>central steady maintained fix</td>
<td>central steady maintained fix</td>
<td>+1.5</td>
<td>+1.5</td>
<td>medial recession</td>
<td>no</td>
<td>endophthalmitis</td>
<td>day 21</td>
<td>uveitis</td>
<td>day 13: cyst &amp; staph</td>
<td>enucleation</td>
<td>enucleation</td>
<td>1.1 year</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>5.5</td>
<td>1955</td>
<td>esotropia</td>
<td>0.9</td>
<td>0.9</td>
<td>medial recession</td>
<td>no</td>
<td>endophthalmitis</td>
<td>day 2</td>
<td>hypopyon</td>
<td>day 7</td>
<td>hypopyon</td>
<td>day 14: clear, haemolyt</td>
<td>VA 0.3</td>
<td>6 weeks</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>5.5</td>
<td>1960</td>
<td>esotropia</td>
<td>central steady maintained fix</td>
<td>central steady maintained fix</td>
<td>-0.75</td>
<td>+1.25</td>
<td>medial recession</td>
<td>no</td>
<td>endophthalmitis</td>
<td>day 7</td>
<td>hypopyon</td>
<td>day 14: clear, haemolyt</td>
<td>VA 1.0</td>
<td>2 weeks</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>6.6</td>
<td>1979</td>
<td>esotropia</td>
<td>residual eso &amp; lat r recession</td>
<td>0.3</td>
<td>0.9</td>
<td>medial recession</td>
<td>no</td>
<td>endophthalmitis</td>
<td>day 14</td>
<td>clear</td>
<td>day 3: vitrectomy</td>
<td>VA 0.3</td>
<td>6 weeks</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>6.5</td>
<td>2005</td>
<td>esotropia</td>
<td>1.0</td>
<td>1.0</td>
<td>0</td>
<td>0</td>
<td>medial recession</td>
<td>no</td>
<td>endophthalmitis</td>
<td>day 3</td>
<td>hypopyon, staph sur</td>
<td>day 3: vitrectomy</td>
<td>VA 1.0</td>
<td>2 weeks</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
The patients are listed according to age. A blank space signifies unknown or unavailable data. 'age' denotes age at surgery, 'SE aff eye' spherical equivalent affected eye, 'SE unaff' spherical equivalent unaffected eye, 'involved rectus' rectus muscle which operation caused endophthalmitis, 'perfor' perforation, 'day 1' first postoperative day, 'VA' decimal visual acuity.
Sutures had been Vicryl in 17 of 17 cases and this was unknown in 9 cases. Among the 10 specified needles were S-4, S-29 and TG-100. No abnormalities regarding sterility were noticed during surgery. In case 13, strabismus surgery was performed together with a circumcision.

**Domain postoperative**

All but 2 patients received antibiotic eye drops and ointment immediately after surgery, in 4 cases this was unknown. The parents of cases 2, 4, 6 and 10 had difficulty administering the antibiotic eye drops or ointment postoperatively, because of lack of cooperation of the child.

The diagnosis of EASS was made in children under 4 on postoperative days 1–4 and in older patients up to 21 days after surgery. The anterior chamber contained a hypopyon in 10 out of 18 eyes of the 17 children. It contained fibrin, plasmoid, 'uveitis' in 3, it was clear in 2, and in 3 cases this was unknown. In adults, hypopyon was seen in only 1 of 7 cases, in 2 cases this was unknown. Bilateral EASS developed in case 2 aged 1. He had fever and bilateral eyelid oedema together with the endophthalmitis.

According to the parents of most young children, their child initially played during the first postoperative day, to become less active or photophobic in the course of the second postoperative day. At the first postoperative visit, the orthoptist or ophthalmologist noticed a red and/or troubled eye in most children. Two adults presented with a painful eye. Patients 6 and 14 had a transient palsy of the involved eye muscle.

Streptococcus pneumoniae and *Haemophilus influenzae* were the most frequent pathogens in children, whereas *S. aureus, S. epidermidis* and *P. aeruginosa* occurred both in children and in elderly.
patients. One culture result had been noted as *haemolytic streptococcus* without further details. The bilateral EASS in case 2 aged 1 was caused by *P. aeruginosa*.

**Domain perforation**

Scleral perforation had not been noticed by the surgeons during surgery in 14 of 14 children (no record in 3), but it had been noticed in 5 of 7 elderly patients (no record in 2).

The histopathology of the enucleated eyes of cases 5, 8, 11 and 18 showed transscleral scarring, compatible with prior full-thickness scleral perforation (Figs 3, 4, 5). In the histopathology examination of case 6, the layers of the sclera beneath the former tract of the suture, that was removed 2 days after EASS was diagnosed, 5 days postoperatively, were found to be undisturbed, but they did contain a scleral channel with nerves and a blood vessel, presumably the long posterior ciliary artery (Fig. 6). This two-year-old girl had developed a right otitis media 3 months before the strabismus surgery with fever up to 41.9°C. Two weeks later esotropia developed, she grasped past objects and stumbled. The paediatric neurologist suspected that a right sixth nerve paresis could have arisen from the otitis media and petrositis. A CT-scan showed aerated petrosal cells, however. She had had a lacrimal duct obstruction of the right eye in the first year of life that had resolved spontaneously. She had been treated for recurrent upper airway infections with Ventolin in the months after the otitis media. A recession of the right medial rectus muscle and a resection of the right lateral rectus muscle was performed for a now concomitant esotropia, together with a posterior tenotomy of the inferior oblique muscle of both eyes. On examination on the third postoperative day, the child was photophobic and had a red, painful eye that looked troubled. No adduction of the right eye was possible for several days, indicative of complete medial rectus palsy, adduction to return to normal in the weeks after. The anterior chamber contained cells, flare and fibrin. An encapsulated, mucoid *H. influenzae* type A was cultured from the vitreous. Weekly ultrasound examinations showed a contracting vitreous, but no retinal detachment or another indication of a perforation. Three weeks postoperatively a cicatricial membrane developed, causing pain at night. A lensectomy with vitrectomy with silicone oil were performed on the 27th postoperative day. After removal of the lens and cicatricial membrane, the retina was found to be attached without retinal defects, but it appeared necrotic nasally. The painful and hypotonic eye was ultimately enucleated 17 months after the strabismus operation. A chronic purulent discharge of the socket developed. Culture of the discharge and deep throat cultures at age 5 again showed an encapsulated, mucoid *H. influenzae*, the same species that had caused the EASS, but multi locus sequence typing of the two strains showed they were not identical. In a subsequent immunological assessment of a panel of 6 antibodies against *S. pneumoniae* capsular polysaccharides, those against serotypes 1, 3, 4, 9 and 23 were undetectable, whereas that against serotype 5 was 0.19 µg/ml (Table 4). Most children have undetectable antibody levels against one or two serotypes, but against 5 out of 6 serotypes is unusual at age 5. As we surmised that an immune defect could contribute to the development of endophthalmitis, patients 5, 8, 10, 19 and 22 were also invited for immunological assessment. Undetectable levels of antibodies were found against only 1 of 6 serotypes in 3 patients, and against 2 of 6 serotypes in patient 9 (Table 4). In case 6, after immunization with *H. influenzae* (Act-Hib®) and *S. pneumoniae* capsular polysaccharides (Pneumovax®), the purulent discharge subsided. In subsequent repeat immunological assessment, the levels of the 6 antibodies against *S. pneumoniae* capsular polysaccharides were adequate (Table 4).

![Fig. 2. Outcome against age when EASS occurred for all 26 cases (27 eyes). The threshold between unchanged or good vision and visual impairment was set arbitrarily at 0.25 (decimal visual acuity).](image-url)
In 7 children, a cyclitic membrane developed, whereas in 3 more cases vitrectomy was performed within a week, precluding the development of a cyclitic membrane. A cyclitic membrane developed in only one of the elderly patients. Vitrectomy was performed in most patients. In all 15 children under age 6 (16 eyes), the affected eye was enucleated, eviscerated or became phthisical. A visual acuity better than 0.25 was attained in 2 out of 4 children aged 6–14 and in 7 out of 9 elderly patients.

**Domain experts' opinion**

At the end, the Case Record Form contained statements regarding EASS to obtain experts’ opinion from those who had operated or treated a case of EASS themselves. The main results are summarized in Table 5. More than half of the ophthalmologists had become more reluctant to operate on the better eye in case of amblyopia, but they had not become more reluctant to let residents operate. Almost all used an information sheet, in addition to oral information, that included the risk of losing vision or the eye. Most did not believe that EASS occurs only after a perforation, nor that a perforation cannot occur if the tip of the needle remains visible through the sclera. Most thought that the first postoperative exam should include an examination by an ophthalmologist. Half thought that too little
attention was given to this complication during residency or orthoptic training.

**Discussion**

By bringing many cases of EASS together we could relate its incidence and outcome to age, operated eye muscle, surgical technique, scleral perforation and immune state.

None of the patients were between 9 and 65 years old, except for one patient with a retinal haemorrhage followed by EASS. In almost all children the EASS resulted from a medial rectus recession. Half of the young children or their siblings had had an upper airway infection. In children, scleral perforation had never been noticed during surgery. The EASS was diagnosed on postoperative day 1-4 in children under 5 years of age. A 2-year-old girl developed EASS and a transient medial rectus palsy 3 days after a medial rectus recession. Histopathology after enucleation one and a half year later showed that the sclera underneath the former suture tract had no signs of full sclera perforation, but it did contain the long posterior ciliary artery. Its channel through the sclera may have allowed bacteria to enter into the eye. In all children under age 6 the eye was enucleated, eviscerated or phthisical. A visual acuity better than 0.25 was attained in 2 out of 4 children aged 6–14 and in 7 out of 9 elderly patients.

Endophthalmitis after strabismus surgery (EASS) between age 6 and 65 years is rare. Bialasiewicz et al. (1990) reported on a 10-year-old boy who had a purulent endophthalmitis 3 days after a medial rectus myopexy, like our case 17 had at the age of 14. In myopexy surgery, the muscle belly is

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**Fig. 5.** Histopathology of the enucleated eye of case 18. Transscleral scarring with cicatrization of the sclera, compatible with prior scleral perforation. Haematoxylin-eosin stain, original magnification 12.5x.

**Table 4.** The immune state was evaluated in patients 5, 6, 8, 10, 19 and 22

<table>
<thead>
<tr>
<th>Patient</th>
<th>Age</th>
<th>Serotype 1</th>
<th>Serotype 3</th>
<th>Serotype 4</th>
<th>Serotype 5</th>
<th>Serotype 9</th>
<th>Serotype 23</th>
</tr>
</thead>
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<tr>
<td>5</td>
<td>15</td>
<td>0.32</td>
<td>3.35</td>
<td>3.83</td>
<td>0.10</td>
<td>1.92</td>
<td>0.22</td>
</tr>
<tr>
<td>6 pre imm.</td>
<td>5</td>
<td>&lt;0.10</td>
<td>&lt;0.10</td>
<td>&lt;0.10</td>
<td>0.10</td>
<td>&lt;0.10</td>
<td>&lt;0.10</td>
</tr>
<tr>
<td>6 post imm.</td>
<td>5</td>
<td>3.62</td>
<td>2.96</td>
<td>1.44</td>
<td>0.39</td>
<td>0.29</td>
<td>0.83</td>
</tr>
<tr>
<td>8</td>
<td>6</td>
<td>0.19</td>
<td>2.67</td>
<td>1.44</td>
<td>0.39</td>
<td>0.29</td>
<td>0.83</td>
</tr>
<tr>
<td>10</td>
<td>12</td>
<td>0.18</td>
<td>&lt;0.10</td>
<td>0.30</td>
<td>0.37</td>
<td>&lt;0.10</td>
<td>0.52</td>
</tr>
<tr>
<td>19</td>
<td>65</td>
<td>0.19</td>
<td>0.43</td>
<td>0.11</td>
<td>0.54</td>
<td>&gt; 7.77</td>
<td>0.90</td>
</tr>
<tr>
<td>22</td>
<td>71</td>
<td>0.69</td>
<td>0.58</td>
<td>0.10</td>
<td>0.74</td>
<td>2.73</td>
<td>1.37</td>
</tr>
</tbody>
</table>

Levels of IgG antibodies (μg/ml) against polysaccharide capsule of *S. pneumoniae* serotypes 1, 3, 4, 5, 9 and 23 were measured, years after the endophthalmitis had occurred. Levels above 0.35 μg/ml are generally considered protective. Patient 6 had undetectable levels against all but one serotypes. She was immunized with *H. influenzae* (Act-Hib®) and *S. pneumoniae* capsular polysaccharides (Pneumovax®). For patient 6, levels before and after immunization are shown.
anchored to the sclera with nonresorbable sutures. The sutures must be placed deep in the sclera, otherwise the sutures are subsequently pulled out of the sclera. Bilateral EASS is also rare. Knoblauch & Lorenz (1962) had 2 bilateral cases among 72 in their survey.

The predilection for EASS to develop in young children and in elderly could be related to the absence of IgG mediated immunity in early childhood and its decline in senescence. The rapid and relentless course of EASS in young children would be compatible with this supposition. An additional explanation could be that adolescents and adults voice
Table 5. To obtain experts’ opinion, the ophthalmologists and the one orthoptist who had operated or treated a case of EASS were asked to agree or not with statements regarding EASS.

<table>
<thead>
<tr>
<th>Statement</th>
<th>10 of 17</th>
<th>2 of 12</th>
<th>9 of 13</th>
<th>14 of 16</th>
<th>8 orthoptists: 1 both: 7</th>
<th>12 of 16</th>
<th>8 of 14</th>
</tr>
</thead>
<tbody>
<tr>
<td>Have you become more reluctant to operate on the better eye in case of</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>amblyopia?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Have you become more reluctant in letting residents operate?</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Can the choice who operates, ophthalmologist or resident, be influenced</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>by the child’s parents?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>For informed consent use information sheet in addition to oral information</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Who should, in your opinion, give this information?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

To obtain experts’ opinion, the ophthalmologists and the one orthoptist who had operated or treated a case of EASS were asked to agree or not with statements regarding EASS.

As found histopathologically after enucleation. This finding confirms the conclusion by Recchia et al. (2000) that ‘the development of EASS neither requires nor implies that full perforation of the sclera has occurred’. In case 6, a complete, transient medial rectus palsy occurred together with the EASS, compatible with bacterial contamination of the suture and subsequent myositis. The scleral channel of the long posterior ciliary artery may have carried bacteria from the contaminated suture into the eye.

Case 6 was a carrier of a mucoid, encapsulated *H. influenzae* type a, found both at age 2 in the eye and at age 5 in the socket, nose and throat. At age 5, she had undetectable levels of antibodies against capsular polysaccharides of all but one *S. pneumoniae* serotype. Some of the capsular polysaccharides of *S. pneumoniae* are homologous with those of *H. influenzae* (Lagergård & Branefors 1983)). Mucoid bacteria produce slime that forms a biofilm on the conjunctiva. They thereby survive antibodies and antibiotics. Half of the children carry *H. influenzae* at age 5, but these are mostly noncapsular strains of *H. influenzae* (Katosova 1994). Before the introduction of Hib vaccination in the Netherlands in 1993, about 700 children annually had a severe *H. influenzae* b infection. After vaccination started this number decreased to 17 in 2001, but it surged again, inexplicably, in children aged 0-4 in 2005 (Rijks Instituut voor de Volksgezondheid, accessed 6 January 2017; McVernon et al. 2004), the year that our case 6 had an invasive *H. influenzae* type a infection and EASS.

In 14 of the 15 children aged 0–6 (16 eyes), the EASS was caused by a medial rectus recession. In case 4 it was caused by a re-resection of a lateral rectus muscle. In a recession, the sclera where the sutures are placed is thinner than the sclera at the original insertion and the long posterior ciliary artery lies more superficially in that area of the sclera. Surachatatumtonekul et al. (2009) found that all 15 perforations among 2195 operated eye muscles in his
study occurred during a recession. In our study, evidence is not very strong, however, as in the Dutch Registry for Strabismus Operations (16) almost 82% of the operations in children were recessions and between 80% and 85% of the operated eye muscles were medial rectus muscles.

The predilection for EASS to occur after medial rectus surgery in children (15 of 16 children aged 0–6) may be related to reflux from the lacrimal sac. The medial rectus muscle lies underneath and between the lacrimal puncta. The nasolacrimal duct can be obstructed functionally by an upper airway infection. Four of the 8 children aged 0–2, or their siblings, had an upper airway infection at the time of surgery. In the study by Recchia et al. (2000), 3 out of 6 children had had an upper airway infection. Good et al. (1990) described three children with endophthalmitis after cataract surgery with either nasolacrimal duct obstruction or upper airway infection at the time of surgery. Kam et al. (2014) found nasolacrimal duct obstruction more often among patients who developed endophthalmitis after cataract surgery as compared to those who did not develop endophthalmitis. Speaker et al. (1991) found the same bacteria in the nose as in the vitreous aspirate in the majority of 17 patients with endophthalmitis after cataract surgery.

For preoperative antisepsis, 10% povidone–iodine solution was used in five cases, 5% in four cases and 1% in three cases. To determine whether differences in effectiveness existed between concentrations, we repeated the study that Ferguson et al. (2003) had performed in adult patients operated for cataract, in children operated for strabismus. In a multicentre, randomized controlled trial (30), we rinsed the conjunctiva either with 5% or with 1.25% povidone–iodine prior to strabismus surgery, in children aged 1–5. After induction of anaesthesia, cultures were taken from the nose, from the conjunctiva and, at the end of surgery, from the reattached eye muscle with cut-off sutures. As has been found by Oliksy et al. (1998), Carothers et al. (2003) and Rogers et al. (2011), many cultures from reattached muscles with cut-off sutures were positive. In several cases, the same bacteria were found on the reattached eye muscle as had been found in the nose before the operation began. In some of these cases, however, cultures taken from the conjunctiva before the operation began were either negative or carried other bacteriae, indicating that the surgical field had been recontaminated during surgery by reflux from the lacrimal sac. Emptying the lacrimal sac by compressing it with a cotton-tipped applicator before rinsing the conjunctiva with povidone–iodine effectively reduced the number of positive cultures from the reattached muscle in that study (Li et al. 2014).

Study limitations
The small sample size limited our ability to perform statistical analysis in this case series. The associations between age and incidence per number of strabismus operations and between age and outcome could, hence, not be statistically secured, nor could the comparatively high EASS rates in young children and in elderly patients be linked to the absence of IgG mediated immunity in early childhood and its decline in senescence, also because the immune status of most patients was unknown. Although in children, EASS occurred almost exclusively after medial rectus recession, this association could not be statistically secured as in the Netherlands around that time more than 80% of the operations in children were recessions and more than 80% concerned medial rectus muscles. Future longitudinal studies with larger sample sizes are required to confirm that age, surgical technique, operated muscle, perforation and immune state are associated with incidence and outcome. Awaiting these results, we can only offer our own policies for consideration: We now postpone strabismus surgery in children under age 6, not only in case of fever, but also if eyes are tearing or nose is running. During preoperative antisepsis, we empty the lacrimal sac by compressing it with a cotton-tipped applicator before rinsing with povidone–iodine. During a recession, we identify the long ciliary posterior artery and steer clear of it with the needle. In many European countries a child is first examined postoperatively by an orthoptist: an orthoptist can check with a retinoscope whether the red-reflex is bright and symmetrical in case of usual complaints.

Age and perforation are key determinants that interact with other factors that determine the occurrence and outcome of EASS. As a model for further research, the causal relations of these with their secondary determinants are depicted, provisionally and open to discussion, in Fig. 7.

Acknowledgements
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Appendix

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