Risk of Glaucoma after Pediatric Cataract Surgery

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PURPOSE. To determine the risk of glaucoma after surgery for pediatric cataract and to evaluate risk factors for glaucoma.

METHODS. A population-based cohort of all children in Denmark aged 0 to 17 years during the period 1977 to 2001, who underwent surgery for pediatric cataract, was established by retrospective chart review. Glaucoma cases were defined as those in which glaucoma surgery (trabeculectomy and/or diode laser transscleral cyclophotocoagulation) was performed and/or permanent medical therapy prescribed after cataract surgery.

RESULTS. Of 946 eyes (595 patients) undergoing pediatric cataract surgery, 72 eyes (48 patients) had subsequent development of glaucoma. Early surgery (<9 months of age) was associated with a 7.2-fold increased risk of glaucoma compared with late surgery (≥9 months of age). Ten years after cataract surgery, glaucoma developed in 31.9% (95% confidence interval [CI], 24.4–41.1) of children undergoing surgery before 9 months of age compared with 4.1% (95% CI, 2.4 to 6.8) of children aged ≥9 months at the time of surgery. Glaucoma cases continued to occur more than 10 years after cataract surgery. After adjustment for age at surgery, no other risk factor appeared important.

CONCLUSIONS. The risk of glaucoma after surgery for pediatric cataract is substantial and particularly high for those below 9 months of age at the time of surgery. Because the increased risk persists for many years after surgery, careful continuous monitoring for glaucoma is mandatory. (Invest Ophthalmol Vis Sci. 2008;49:1791–1796) DOI:10.1167/iovs.07-1156

One of the most severe complications after surgery for congenital cataract is glaucoma. However, reported incidences of glaucoma after congenital cataract surgery vary. Because of differences in study population, criteria for diagnosis of glaucoma, and length of follow-up period, the frequencies of postoperative glaucoma have been reported to be between 8% and 59%.8–11 Similarly, several risk factors (e.g., surgery at a very early age12–14 microcornea,4–7,15 nuclear cataract morphology,6,7,12,15 surgical technique,6 and surgery for secondary cataract6,14) have been suggested to be associated with glaucoma after cataract surgery, but with other reports not being able to find one or more of these associations.8,12,15,16 Furthermore, some studies find primary intracocular lens implantation to be protective against glaucoma.17–19 but others do not.16,20–23 The uncertainties between previously reported studies are perhaps because most studies have been based on smaller sample sizes. Previous larger reports on risk factors for glaucoma have been on selected groups of aphakic children,6,11 and have found age at surgery, small corneas, surgery for secondary cataract and primary surgery with posterior capsulotomy-anterior vitrectomy to be risk factors for development of glaucoma.

We took advantage of the national registration of pediatric cataract surgery in Denmark to establish a population-based cohort of all children who underwent surgery for pediatric cataract from 1977 to 2005. Our objective was to investigate the risk of glaucoma after surgery according to cataract etiology, surgical technique, surgery for secondary cataract, cataract morphology, other ocular anomalies, age at surgery, and time since surgery.

METHODS

Ascertainment of Cases

Since 1977 all discharge diagnoses and surgical procedures of patients admitted to public hospitals have been registered in the Danish National Register of Patients (NRP). Since 1995 outpatients have also been registered. Based on the information in NRP we established a cohort of all children from birth to 17 years and diagnosed with pediatric cataract during the period 1977 to 2001. We subsequently contacted all relevant hospitals and were able to retrieve and review the children’s medical records. Additional case information was obtained from the consultant ophthalmologists who provided care when needed. Cataracts were classified by etiology, and those caused by trauma (n = 466), or considered to be due to acquired systemic (e.g., diabetes) or acquired ocular disease (e.g., uveitis; n = 258) were excluded.24–26 The final cohort consisted only of those who underwent cataract surgery during the period 1977 to 2005. For the present analysis cases reported with aniridia (n = 13), congenital rubella (n = 17), and Lowe’s syndrome (n = 1) were excluded, because these cases are independently associated with glaucoma. Cases with persistent fetal vasculature (PFV) and microcornea were included for the purpose of studying the risk of these conditions with the development of glaucoma. Microcornea was defined as 2 standard deviations below the mean corneal diameter, according to postconceptional age and otherwise as <10 mm in diameter.20–27

The cases were classified according to etiology and clinical characteristics. The main etiological groups were idiopathic, hereditary, and familial, associated with syndromes and chromosomal anomalies, and associated with intrauterine infection.25 Clinically, the cases were divided by laterality (unilateral or bilateral cataracts) and into groups including isolated cataracts and cataracts associated with additional anomalies (ocular dysmorphology and/or systemic anomalies denoted cataract plus). Data on cataract morphology were grouped into nuclear, zonular and other (non-nuclear).

In the first categorization, cataract surgery was divided into three groups: (1) Cataract surgery by lensectomy using either a suction-
irrigation technique or phacoemulsification with or without posterior capsulorrhexis or capsulotomy; (2) cataract surgery by lensectomy by either the suction–irrigation technique or phacoemulsification with posterior capsulorrhexis and anterior vitrectomy; and (3) unspecified. We made another categorization to investigate whether the risk of glaucoma is associated with a break in the posterior capsule and lensectomy with a break in the posterior capsule or posterior capsulorrhexis, both at the primary surgery.

The use of intraocular pressure (IOP) as the sole indicator of glaucoma is probably not sufficient, especially in young children, in whom, for example, myopic shift or increased optic disc cupping may be the first sign of glaucoma.26 We therefore defined glaucomatous eyes as eyes that the consultant decided required permanent medical therapy and/or surgical therapy (trabeculectomy and/or diode laser transscleral cyclophotocoagulation). Eyes with transient elevation of IOP that could be controlled with an iridectomy or anterior vitrectomy were not defined as cases of secondary glaucoma.

We excluded cataract cases that did not have a postoperative measurement of IOP, because a postoperative measurement of IOP was taken as a proxy for a glaucoma evaluation, and without a glaucoma evaluation the cases could not be classified as glaucoma or nonglaucoma cases.

Permission to receive data from the national registries was obtained from the Danish Data Protection Agency (2000-41-0285). The study was approved by the Scientific-Ethical Committees for Copenhagen and Frederiksberg (KF 01-253/00), and it adhered to the tenets of the Declaration of Helsinki.

**Statistical Analyses**

All analyses were based on eyes as the unit. The rate ratios (RRs) of glaucoma after surgery of pediatric cataract according to age at surgery and various characteristics were estimated by a Cox proportional hazards regression model (the Proc Phreg feature of SAS statistical software; SAS, Cary, NC). Time at risk (i.e., follow-up time) was defined for each eye as the time from surgery until glaucoma diagnosis, last measurement of IOP, emigration, or death, whichever came first. Time of glaucoma diagnosis was defined as the interval midpoint between time of last measurement “without glaucoma” and first “with glaucoma.” In two additional sensitivity analyses, time of glaucoma diagnosis was defined as time of last measurement “without glaucoma” and time of first measurement “with glaucoma,” respectively. Adjustment for age at surgery was performed by including age in the regression model with the following categories (in months): 0 to 1; 1 to <2; 2 to <3, 3 to <4, 4 to <5, 5 to <6, 6 to <9, 9 to <12, 12 to <15, 15 to <18, 18 to <21, 21 to <24, 24 to <36, 36 to <48, 48 to <60, 60 to <72, 72 to <84, and ≥84. Adjustment for correlation between eyes was obtained using robust standard errors,30 resulting in slightly wider confidence intervals on estimated RRs. In the Cox proportional hazards model proportional hazards are assumed over time. That the hazards were proportional over time since surgery was supported by the fact that there were no effect modifications by time since surgery (see the Results section). Proportion of children without glaucoma at a given time after surgery was estimated by Kaplan-Meier estimates (Proc Lifetest; SAS).

**RESULTS**

Overall, 202 patients with a validated diagnosis of pediatric cataract did not undergo cataract surgery, most because the cataract was not visually significant. These patients were not included in the analyses. None of them was registered with glaucoma surgery or received any antiglaucoma medical treatment, and almost half of the cases had a registration of a normal IOP measurement. In most of the nonsurgical cases, repeated examinations by ophthalmologists had not revealed glaucoma.

Of 697 eligible patients with pediatric cataract and surgery, we subsequently excluded surgically treated eyes that lacked any postoperative measurement of IOP, as IOP was used as a proxy for an evaluation of glaucoma. A total 946 eyes (595 patients: 306 males, and 289 females) remained in the study. Bilateral lensectomy was performed in 351 patients (702 eyes), and 244 patients had unilateral cataract surgery, 62 patients of the latter group having bilateral cataract. The median follow-up time since surgery was 4.2 years (25% quartile, 0.67 years; 75% quartile, 9.7 years).

Secondary glaucoma developed in 72 (48 patients) of the 946 eyes that had had cataract surgery. Bilateral glaucoma was present in 24 patients. The median time interval between surgery and glaucoma diagnosis was 6.6 years (25% quartile, 1.1 years; 75% quartile, 10.7 years).

Table 1 gives the number of surgically treated and subsequently glaucomatous eyes and median follow-up time by age at surgery. The risk of glaucoma after cataract surgery was highly dependent on age at surgery (P < 0.001). Compared with children who underwent surgery at an age of 2 years or more, the RR of glaucoma was increased between 5.8- and 9.4-fold among children undergoing surgery within the first 8 months of life (Table 1). During the first 8 months of age, the risk of glaucoma did not vary significantly by age at surgery.

Table 2 presents the cumulative risk of glaucoma by years since surgery, according to whether children had had cataract surgery before or after 9 months of age.

We further investigated the influence of surgical procedures, cataract presentation, and cataract etiology on the subsequent risk of glaucoma. Table 3 gives the RRs of developing glaucoma according to type of surgery, surgery for secondary cataract, other ocular anomalies, cataract etiology, clinical

### Table 1. Number of Surgical Eyes and Subsequently Glaucomatous Eyes, Median Follow-up Time, and RR Stratified by Age at Surgery and Time since Cataract Surgery

<table>
<thead>
<tr>
<th>Age at Surgery (mo)</th>
<th>Surgical Eyes (n)</th>
<th>Glaucomatous Eyes, n (%)</th>
<th>Median Follow-up Time (y)</th>
<th>10-y risk (95% CI)</th>
<th>RR (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0–1*</td>
<td>39</td>
<td>10 (26)</td>
<td>6.2</td>
<td>30.5 (15.0–55.7)</td>
<td>9.4 (3.6–24.1)</td>
</tr>
<tr>
<td>2</td>
<td>30</td>
<td>5 (17)</td>
<td>3.6</td>
<td>22.9 (8.3–54.0)</td>
<td>5.8 (2.1–16.1)</td>
</tr>
<tr>
<td>3–5</td>
<td>116</td>
<td>25 (22)</td>
<td>5.5</td>
<td>34.4 (23.8–48.0)</td>
<td>7.8 (3.9–15.7)</td>
</tr>
<tr>
<td>6–8</td>
<td>52</td>
<td>12 (23)</td>
<td>4.4</td>
<td>34.4 (19.6–55.7)</td>
<td>8.5 (3.5–20.5)</td>
</tr>
<tr>
<td>9–11</td>
<td>30</td>
<td>1 (3)</td>
<td>7.9</td>
<td>0</td>
<td>0.92 (0.12–6.86)</td>
</tr>
<tr>
<td>12–23</td>
<td>59</td>
<td>4 (7)</td>
<td>6.5</td>
<td>8.1 (2.5–24.2)</td>
<td>2.0 (0.64–6.3)</td>
</tr>
<tr>
<td>24+</td>
<td>620</td>
<td>15 (2)</td>
<td>2.9</td>
<td>3.7 (2.1–6.7)</td>
<td>1</td>
</tr>
<tr>
<td>0–8</td>
<td>237</td>
<td>52 (22)</td>
<td>5.3</td>
<td>31.9 (24.4–41.1)</td>
<td>7.2 (4.1–12.5)</td>
</tr>
<tr>
<td>9+</td>
<td>709</td>
<td>20 (3)</td>
<td>3.8</td>
<td>4.1 (2.4–6.8)</td>
<td>1</td>
</tr>
</tbody>
</table>

* Includes the first 8 weeks of life. Seven subjects underwent surgery during the first 4 weeks of life, and glaucoma developed in one.
manifestation of the cataract, laterality, implantation of intracor- 
neal lens, and cataract morphology. The unadjusted risk of 
glaucoma was lower in eyes who had a primary intraocular lens 
implantation and higher in eyes having had surgery by lensec- 
tomy with posterior capsulorrhexis and anterior vitrectomy, in 
eyes where the posterior capsule was not left intact, in eyes with 
preoperative nystagmus, and in eyes with cataract asso- 
ciated with other ocular and/or systemic disease (cataract 
plus). However, none of these variables remained significantly 
associated with glaucoma after adjustment for age at surgery.

Further stratification by age at surgery (before and at or after 
9 months of age) revealed effect modifications by age at surgery 
for laterality and for microcornea. In eyes of children aged 9 
months or more at surgery, there was a higher risk of glaucoma 
associated with having unilateral cataract ($\text{RR}_{\text{effect modification}} = 0.05$) and microcornea ($\text{RR}_{\text{effect modification}} < 0.0001$); however, the 
majority (77%) of patients with unilateral cataract underwent 
surgery at more than 9 months of age, whereas the majority (71%) 
of eyes with microcornea underwent surgery at less than 9 
months. The RRs of the variables given in Table 3 did not differ 
depending on time since surgery ($<\pm$5 years, data not shown).

In subsequent analyses with adjustment for age at surgery, 
we tested whether cataract surgery by pars plana lensectomy and 
vitrectomy differed in glaucoma risk from other types of surgery, 
but found that they had similar rate ratios (RR$_{\text{pars plana versus other}} = 0.75$; 95% CI, 0.20–2.76). Moreover, there was no difference in 
the glaucoma risk between right and left eyes (RR$_{\text{left versus right}} = 0.98; 95\% \text{ CI, } 0.72–1.35$), between sexes (RR$_{\text{boy versus girl}} = 0.85$; 
95% CI, 0.47–1.54), or according to the surgical experience of the 
ophthalmologist (RR $\geq 50$ vs. $<50$ surgeries $= 0.62$; 95% CI, 
0.34–1.15).

Time of glaucoma diagnosis is not necessarily the same as 
the time of debut. We therefore used the midpoint between 
cataract surgery or last normal measurement of IOP until glau- 
coma was first registered as an approximation of the time of 
debut. Additional sensitivity analyses using right and left end-
points instead of midpoints revealed that the conclusions 
drawn were not dependent on this approximation.

In addition to the 246 surgical eyes included in the analyses, 
there were 91 patients (134 eyes) for whom we had a date of 
latest visit to an ophthalmologist but no postoperative mea-
surement of IOP, and 11 patients (14 eyes) with no record of 
a postoperative visit to an ophthalmologist. As a sensitivity 
analysis, we added these patients as follows: the first group was 
assigned a follow-up time equal to the time of the latest visit, 
and the latter group was assigned the median follow-up time 
for eyes operated on in the same 5-year calendar period. 
Including these eyes in the analyses and assuming that none of 
them developed glaucoma gave very similar results. Compared 
with eyes in children that were 9 months of age or older at 
surgery, the rate of glaucoma was 7.85-fold (4.51–13.66) 
higher in children with age at surgery less than 9 months. The 
cumulative risk estimates after 10 years in this analysis were 
29.2% (95% CI, 22.2%–37.8%) for those with an age at cataract 
surgery of less than 9 months compared with 3.4% (95% CI, 
2.0%–5.7%) for those with an age at surgery of 9 months or 
more.

**Discussion**

Based on a large population-based cohort of all children who 
had undergone surgery for pediatric cataract, we found age at 
surgery (<9 months) to be the only important factor for sub-
sequent risk of glaucoma among several potential risk factors. 
Ten years after cataract surgery, 31.9% (95% CI, 24.4–41.1) of 
the children who underwent surgery before 9 months of age 
had developed glaucoma compared with 4.1% (95% CI, 2.4– 
6.8) of children who were older at time of surgery. None of 
the children with pediatric cataract who never underwent surgery 
had subsequent development of glaucoma.

The study had several strengths, including its large size and 
its population-based cohort design. Based on mandatory na-
tional registration, we were able to retrieve all children with 
a diagnosis of pediatric cataract and over many years to follow 
these children with respect to glaucoma development. We 
thereby avoided significant problems with selection bias and 
differential misclassification. Previously published larger stud-
ies on glaucoma after pediatric cataract surgery based the 
definition of glaucoma on IOP. There is a risk that in lower 
age groups this definition may lead to an underestimation of 
glaucoma because IOP in infancy is not always increased in 
glaucoma; rather, there is often an increased cupping of the 
optic disc and/or an extraordinary decrease in hyperopia, which 
may result from an overestimation on the method of measurement, 
but also when central corneal thickness, for example, is not taken into consideration. In fact, it has been suggested that children who had lensectomy with or without IOL implantation have a higher corneal thickness mea-
surement and thereby the IOP measurement may be artificially 
elevated. Because of the retrospective nature of our study, 
we chose to rely on the consultants' diagnosis of glaucoma 
(i.e., their decision to start surgical and/or long-term medical 
treatment for glaucoma) to avoid the risk of misclassification. 
Furthermore, we chose to exclude cases that did not have a 
postoperative measurement of IOP, because we made the 
assumption that measuring the IOP was an indication of glau-
coma evaluation. Children without any postoperative glau-
coma evaluation could neither be categorized as glaucoma 
cases or nonglaucoma cases. However, measuring IOP may 
indicate suspicion of glaucoma or that the surgeon recognized 
that the patient was in a high-risk group. We therefore per-
formed additional analyses, where we also included children 
without any postoperative glaucoma evaluation and as a worst-
case scenario assumed that none of them had ever had glau-
coma. As the results of these analyses were similar to the main 
results, we do not think that exclusion of children without any 
postoperative glaucoma evaluation has biased our results.

Age at surgery as a risk factor for glaucoma after pediatric 
cataract surgery has been investigated in previous studies and 
the following age periods have been suggested to be associated 
with the highest risk of glaucoma: >2 weeks of life,15 the first 
few months of life,12,13 ≤9 months of age,10 <1 year of 
age,11,14 and <15 months of age. In our study, the risk of 
glaucoma was significantly lower when having surgery at the 
age of ≥9 months. We were not able to find any difference in 
risk during the first 8 months of life, which is comparable to

**Table 2. Risk of Glaucoma by Time since Surgery According to Age at Surgery**

<table>
<thead>
<tr>
<th>Time since Surgery</th>
<th>0-8 Months</th>
<th>9+ Months</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 year</td>
<td>5.4 (3.2–9.6)</td>
<td>0.7 (0.3–1.9)</td>
</tr>
<tr>
<td>2 years</td>
<td>7.5 (4.7–12.0)</td>
<td>1.1 (0.5–2.5)</td>
</tr>
<tr>
<td>3 years</td>
<td>8.1 (5.1–2.7)</td>
<td>1.6 (0.8–3.2)</td>
</tr>
<tr>
<td>4 years</td>
<td>9.3 (6.1–12.7)</td>
<td>1.6 (0.8–3.2)</td>
</tr>
<tr>
<td>5 years</td>
<td>12.7 (8.7–18.6)</td>
<td>1.8 (1.6–5.0)</td>
</tr>
<tr>
<td>6 years</td>
<td>18.8 (13.5–25.8)</td>
<td>1.8 (1.6–5.0)</td>
</tr>
<tr>
<td>7 years</td>
<td>23.0 (15.6–31.9)</td>
<td>3.2 (1.8–5.6)</td>
</tr>
<tr>
<td>8 years</td>
<td>26.2 (19.6–34.4)</td>
<td>5.6 (2.1–6.1)</td>
</tr>
<tr>
<td>9 years</td>
<td>31.9 (24.4–41.1)</td>
<td>4.1 (2.4–6.8)</td>
</tr>
<tr>
<td>10 years</td>
<td>31.9 (24.4–41.1)</td>
<td>4.1 (2.4–6.8)</td>
</tr>
</tbody>
</table>

Data are the RRs of glaucoma (95% CI).
Vishwanath et al. \(^ {13} \) have reported that the cumulative risk of glaucoma by 5 years among eyes operated on before 1 year of age was 15.6\% (95\% CI, 10.2–23.4), with similar risk reported in age groups corresponding to ours.\(^ {6,11} \) We found the cumulative risk of glaucoma 5 years after cataract surgery to be 12.7\% (95\% CI, 8.7–18.6) for eyes of children operated on before 9 months of age and 1.8\% (95\% CI, 1.6–5.0) for eyes undergoing surgery at 9 months of age or after—the corresponding statistics 10 years after surgery being 31.9\% (95\% CI, 24.4–41.1) and 4.1\% (95\% CI, 2.4–6.8), respectively.

Although surgery is the necessary and sufficient event, the exact mechanism causing the type of glaucoma after surgery for congenital cataract is not well understood. Postoperative inflammation of the trabecular meshwork (the loss of mechanical support to the trabecular meshwork) or vitreous substances that are toxic to the trabecular meshwork may be involved.\(^ {28} \) There have been several reports of risk factors associated with glaucoma,\(^ {4–8,12,14,15–17,23,32} \) but with inconsistent results.

Two previously published larger studies on risk factors did not include children with primary intraocular lens implantation.\(^ {6,11} \) Furthermore, Rabiah\(^ {6} \) excluded children with a follow-up of <5 years, which may have led to selection bias. The other study, by Chen et al.,\(^ {11} \) was based on patients seen by a glaucoma specialist, also leading to possible selection bias, which is reflected in the high percentage of aphakic glaucoma reported in this study (58.7\%). However, both studies found age at surgery, microcornea, and surgery for secondary cataract to be risk factors, and Rabiah\(^ {6} \) also found primary posterior

<table>
<thead>
<tr>
<th>Variable</th>
<th>Glaucomatous Eyes*</th>
<th>Surgical Eyes*</th>
<th>RR (95% CI)</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>Unadjusted</td>
<td>Adjusted†</td>
<td></td>
</tr>
<tr>
<td>Type of surgery</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lensectomy</td>
<td>43 640</td>
<td>1 1</td>
<td></td>
</tr>
<tr>
<td>Lensectomy, anterior vitrectomy</td>
<td>27 269</td>
<td>2.30 (1.28–4.14)</td>
<td>1.56 (0.82–2.98)</td>
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<tr>
<td>Unspecified</td>
<td>2 37</td>
<td>1.07 (0.25–4.61)</td>
<td>1.00 (0.21–4.70)</td>
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<tr>
<td>Posterior capsule</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Intact</td>
<td>30 506</td>
<td>1 1</td>
<td></td>
</tr>
<tr>
<td>Not intact</td>
<td>40 403</td>
<td>2.13 (1.22–3.72)</td>
<td>1.26 (0.68–2.34)</td>
</tr>
<tr>
<td>Surgery for secondary cataract‡</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>None</td>
<td>41 —</td>
<td>1 1</td>
<td></td>
</tr>
<tr>
<td>Once</td>
<td>22 —</td>
<td>1.09 (0.58–2.07)</td>
<td>1.21 (0.66–2.23)</td>
</tr>
<tr>
<td>Twice or more</td>
<td>9 —</td>
<td>1.28 (0.56–2.93)</td>
<td>1.15 (0.46–2.86)</td>
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<td>Nystagmus</td>
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<tr>
<td>No</td>
<td>49 806</td>
<td>2.13 (1.11–4.11)</td>
<td>1.26 (0.61–2.59)</td>
</tr>
<tr>
<td>Yes</td>
<td>22 134</td>
<td>1.00 (0.21–4.70)</td>
<td>1.00 (0.21–4.70)</td>
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<tr>
<td>PFV</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>No</td>
<td>69 905</td>
<td>1.14 (0.30–4.39)</td>
<td>1.41 (0.37–5.41)</td>
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<tr>
<td>Yes</td>
<td>2 55</td>
<td>1.05 (0.47–2.34)</td>
<td>1.16 (0.47–2.87)</td>
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<tr>
<td>Microcornea</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>No</td>
<td>38 188</td>
<td>1 1</td>
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</tr>
<tr>
<td>Yes</td>
<td>15 58</td>
<td>1.05 (0.47–2.34)</td>
<td>1.16 (0.47–2.87)</td>
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<td>Etiology</td>
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<td>Nonhereditary</td>
<td>50 581</td>
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<td>Hereditary</td>
<td>22 343</td>
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<td>0.68 (0.38–1.24)</td>
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<td>Clinical manifestation</td>
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<tr>
<td>Isolated cataract</td>
<td>43 744</td>
<td>1 1</td>
<td></td>
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<tr>
<td>Cataract plus</td>
<td>29 202</td>
<td>2.26 (1.23–4.14)</td>
<td>1.65 (0.85–3.17)</td>
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<td>Laterality</td>
<td></td>
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</tr>
<tr>
<td>Bilateral</td>
<td>65 759</td>
<td>1 1</td>
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<td>Unilateral</td>
<td>7 187</td>
<td>0.59 (0.26–1.32)</td>
<td>1.39 (0.58–3.33)</td>
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<td>Primary intraocular lens implantation</td>
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</tr>
<tr>
<td>No</td>
<td>66 619</td>
<td>1 1</td>
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<tr>
<td>Yes</td>
<td>6 527</td>
<td>0.37 (0.14–0.99)</td>
<td>0.77 (0.28–2.12)</td>
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<td>Morphology</td>
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<td></td>
</tr>
<tr>
<td>Other</td>
<td>7 212</td>
<td>1 1</td>
<td></td>
</tr>
<tr>
<td>Nuclear</td>
<td>35 498</td>
<td>1.84 (0.67–5.03)</td>
<td>2.19 (0.83–5.79)</td>
</tr>
</tbody>
</table>

* The number of cases differs between risk factors due to unspecified or missing information.† Adjusted for age at surgery.‡ Time dependent variable; performed before diagnosis of glaucoma.
capsulotomy–anterior vitrectomy to be a risk factor for aphakic glaucoma. The latter result was uncertain, however, because there were a few surgical cases involving another surgical technique. In our study, we were able to investigate various risk factors for glaucoma, including primary IOL implantation and surgical technique.

In our study, we found some of these previously reported potential risk factors (e.g., age at surgery, primary IOL implantation, and surgery with posterior capsulotomy and anterior vitrectomy) to be associated with glaucoma in univariate analyses. Age at surgery turned out to be the most important risk factor for later glaucoma development, so that when adjustment was made for age at surgery, the other associations were no longer present. Likewise, in a recent study by Trivedi et al.16 no association between primary IOL implantation and microcornea and postoperative development of glaucoma after pediatric cataract surgery could be found when subjects were stratified according to age at surgery of ≤6 months and >6 months.

The optimal time for congenital cataract surgery considering both visual outcome and the potential for postoperative complications, especially glaucoma, is currently debated. To achieve good visual acuity, early surgery (before the age of 6–10 weeks) depending on laterality32–36 is favored. In one study, the risk of developing glaucoma after surgery in these first critical months has been reported to be highest during the first 4 weeks of life.13 However, in our study, only one of seven patients operated on within the first month of life had subsequent development of glaucoma, and we saw no indication that the effects of surgery within the first 2 months of life differ compared with the months immediately following, up to 8 months of age. We note, however, that few Danish infants underwent surgery the first month, perhaps because Denmark lacks screening procedures (red reflex) used for assessing the presence of congenital cataract in the newborn child. Another reason may be that surgeons previously have been reluctant to operate on infants less than 2 months of age. Thus, we were not able to draw any firm conclusions regarding the safety of surgery during the very first weeks of life.

The mean interval between primary cataract surgery and glaucoma development has been reported to be approximately 4 to 5 years,6,10,37 but there have been reports of cases occurring several decades later.4,5,26,57,58 It is obvious that measurement of IOP and other relevant measurements such as axial length in small children below 4 to 5 years of age are difficult, and in most cases a comprehensive eye examination requires general anesthesia of the infant. In Denmark there are not yet any national recommendations on when and how frequently children who have had surgery for pediatric cataract should be examined. In addition, some of the cases included in this study are from a time when the focus on glaucoma after pediatric cataract surgery was low; hence, the discovery of glaucoma may have been delayed in some early cases. Our study supports that patients who undergo surgery for pediatric cataract should be examined regularly for glaucoma throughout their lives. In the present investigation new cases of glaucoma continued to be diagnosed at a high rate, even 10 years after cataract surgery.

In conclusion, we found that surgery for pediatric cataract during the first 8 months of life was associated with a substantially increased risk of glaucoma, whereas surgery at ≥9 months of age resulted in a lower risk. Glaucoma developed anytime after surgery, as much as ≥10 years later, prompting both early and long-term follow-up of these children. However, bilateral central and/or dense congenital cataracts often leave the clinicians with little choice regarding age of surgery because of the risk of amblyopia, with the viable way being the close follow-up of children with early surgical intervention.

References


25. Haargaard B, Wohlfahrt J, Fledelius HC, Rosenberg T, Melbye M. A nationwide Danish study of 1027 cases of congenital/infantile


