The Spectrum of Iatrogenic Intraocular Injuries Caused by Inadvertent Cannula Release During Anterior Segment Surgery

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Objective: To evaluate the causes of inadvertent intraocular injuries resulting from the use of cannulas during anterior segment surgery.

Method: Retrospective review of all cases with inadvertent release of irrigation and viscoelastic cannulas during anterior segment surgery in 15 years.

Results: Inadvertent release of cannulas occurred in 9 of 10,230 cases of anterior segment surgery during a 15-year period. The incidence of cannula release was 0.88 per 1000 procedures per year. Twenty percent of the surgeons who performed anterior segment surgery in this period were involved in this unfortunate event. Six cases occurred during cataract extraction and 3 during penetrating keratoplasty or replacement of corneal graft. The latter 3 cases included posterior capsule rupture and vitreous loss. Macular scar in 2 (22%) of the 9 cases was associated with poor visual outcome of counting fingers at 2.1 to 3.0 m (P = .03). In all other surgeries, the cannula caused iris or anterior chamber angle injury without consequences.

Conclusions: Inadvertent release of cannulas during anterior segment surgery is a rare, memorable, and unfortunate event. The severity of the injury may be related to the type of the surgical wound. In most cases, visual outcome is not compromised unless the cannula causes retinal disruption.

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INTAOPERATIVE COMPLICATIONS may occur during cataract surgery because of poor surgical technique; inadvertent movement of the patient’s head, the operated eye, or the surgeon’s hand; and to a lesser extent, inherent anatomic and pathologic variations of the patient’s eye. The incidence of intraoperative complications during extracapsular cataract extraction and phacoemulsification with posterior chamber intraocular lens implantation is between 3% and 9.3%.1-3 The spectrum of these complications is well known and has been reviewed in the past. However, to our knowledge, iatrogenic complications caused by irrigation and viscoelastic cannulas during anterior segment surgery have not been systematically studied as determined by a MEDLINE literature search using the terms cannula, cataract surgery, phacoemulsification, penetrating keratoplasty, triple procedure, and trabeculectomy. Only 2 case reports addressed intraocular damage by cannulas.4,5 This is surprising because cannulas are used during most stages of anterior segment procedures, and most surgeons probably have encountered such inadvertent release of cannulas during cataract surgery as residents or attending physicians. Possible explanations for the lack of literature on this subject are lawsuits or the rare nature of this complication. Nevertheless, this subject is a public health concern and surgeons should be aware of it.

The purpose of this study was to investigate the settings in which such release can occur, the spectrum of injuries caused by the release of cannulas, and their incidence. We also discuss measures to prevent this event and the treatment of different types of injuries.

METHODS

We retrospectively reviewed all cases in which either irrigation or a viscoelastic cannula was accidentally released in the eye when injecting balanced salt solution or viscoelastic agent during anterior segment surgery. This evaluation was performed for all the anterior segment procedures between January 1, 1986, and December 31, 2000, at our tertiary referral center. We recorded the preoperative status, type of surgery, mechanism and site of injury, late impact, and visual outcome of these cases. The follow-up period was 1 month in the outpatient clinic for uncomplicated cases and 12 to
During 15 years, 8318 patients underwent cataract extraction, 1490 underwent corneal transplantation or triple procedure, and 422 underwent filtration surgery. In 9 of these procedures, cannulas were inadvertently released (Table). Thus, the calculated incidence of such events was 0.88 per 1000 procedures per year. Five men and 4 women were involved. The age range was 49 to 78 years. The left eye was involved in 5 patients, and the right eye in 4. Six of these events occurred during cataract extraction (0.07% of all cataract surgery procedures), 2 occurred during penetrating keratoplasty, and 1 during replacement of corneal transplant in a pseudophakic eye (0.2% of all penetrating keratoplasties). No case was recorded during filtration procedures.

Accidental cannula release occurred with 4 (20%) of the 20 surgeons performing anterior segment surgery at the department during the study period. Two (13%) of 15 ophthalmic residents and 2 (40%) of 5 attending physicians experienced this phenomenon during that period.

A viscoelastic cannula was involved in 3 cases. In these cases, cannulas were released in the early stage of surgery, when a viscoelastic agent was injected to cover the iris diaphragm. In the other 6 cases, an irritation cannula containing balanced salt solution was released. Among these latter cases, the cannulas were released during hydroscleral injection in 1, during anterior chamber reestablishment in 2, and during later-stage stromal hydration of the corneal paracentesis in 3.

Among the 6 events that occurred during cataract extraction, the cannula struck the iris on 1 occasion without causing hemorrhage or tear. On 2 other occasions, the cannula struck the anterior chamber angle, of which 1 developed hyphema. The corneal endothelium was injured in 1 case and temporary corneal edema developed, and vitreous loss occurred in 2 other cases. In all 3 cases that occurred during penetrating keratoplasty or corneal graft replacement, the posterior capsule was ruptured and the posterior segment was involved (P = .01). In 2 of these cases (22% of all cases), the cannula struck the macula. The cases with capsule rupture were managed by anterior vitrectomy and placement of posterior chamber intraocular lens.

84 (mean, 48) months in the outpatient clinic for sight-related complications. All patients were followed up for at least 5 years by their referring ophthalmologists. Statistical analysis was performed with Fisher exact test for samples with an expectancy of less than 5, and P < .05 was considered statistically significant. No institutional review board approval was required for the study.

Table. Characteristics of Patients Injured by Inadvertent Release of Cannula During Anterior Segment Surgery

<table>
<thead>
<tr>
<th>Patient No./Sex/Age, y</th>
<th>Involved Eye</th>
<th>Visual Acuity at Presentation and Diagnosis</th>
<th>Type of Surgery</th>
<th>Type of Cannula/Step</th>
<th>Area of Impact</th>
<th>Type of Injury</th>
<th>Late Sequelae</th>
<th>Management</th>
<th>Visual Acuity Before Surgery</th>
<th>Final Visual Acuity (Additional Findings)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/M/53</td>
<td>R</td>
<td>Immune graft rejection</td>
<td>Third penetrating keratoplasty in pseudophakic eye</td>
<td>Temporal to fovea</td>
<td>Blunt macular contusion</td>
<td>Macular scar, epithelial membrane</td>
<td>Anterior vitrectomy</td>
<td>0.3 m CF</td>
<td>3.0 m CF</td>
<td></td>
</tr>
<tr>
<td>2/F/78</td>
<td>L</td>
<td>1.8 m CF Aphakic bullous keratopathy s/p anterior vitrectomy</td>
<td>Penetrating keratoplasty</td>
<td>Fovea</td>
<td>Vitreous loss, blunt macular contusion</td>
<td>Macular scar</td>
<td>Anterior vitrectomy</td>
<td>3.0 m CF</td>
<td>2.1 m CF</td>
<td></td>
</tr>
<tr>
<td>3/M/73</td>
<td>R</td>
<td>Aphakic bullous keratopathy</td>
<td>Penetrating keratoplasty</td>
<td>Vitreous</td>
<td>Vitreous loss</td>
<td>None</td>
<td>Anterior vitrectomy</td>
<td>1.8 m CF (ARMD)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4/M/69</td>
<td>L</td>
<td>Posterior subcapsular cataract</td>
<td>ECCE and PC-IOL</td>
<td>Iris</td>
<td>Iris and angle contusion</td>
<td>None</td>
<td>None</td>
<td>20/200</td>
<td>20/20</td>
<td></td>
</tr>
<tr>
<td>5/M/49</td>
<td>R</td>
<td>Cataract</td>
<td>ECCE and PC-IOL</td>
<td>Anterior chamber</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>20/100</td>
<td>20/25</td>
<td></td>
</tr>
<tr>
<td>6/F/66</td>
<td>R</td>
<td>Nuclear cataract</td>
<td>ECCE and PC-IOL</td>
<td>Cornea</td>
<td>None</td>
<td>Frequent topical corticosteroids</td>
<td>20/100</td>
<td>20/40</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7/F/61</td>
<td>L</td>
<td>Brunescence cataract</td>
<td>ECCE and PC-IOL</td>
<td>Vitreous</td>
<td>Iris tear, capsular tear, vitreous loss</td>
<td>None</td>
<td>Anterior vitrectomy</td>
<td>0.6 m CF</td>
<td>20/40</td>
<td></td>
</tr>
<tr>
<td>8/F/72</td>
<td>L</td>
<td>Brunescence cataract</td>
<td>ECCE and PC-IOL</td>
<td>Vitreous</td>
<td>Capsular tear, vitreous loss</td>
<td>None</td>
<td>Anterior vitrectomy</td>
<td>0.6 m CF</td>
<td>20/100 (AION)</td>
<td></td>
</tr>
<tr>
<td>9/M/65</td>
<td>L</td>
<td>Nuclear cataract</td>
<td>Phacoemulsification and PC-IOL</td>
<td>Anterior chamber angle</td>
<td>Angle contusion</td>
<td>Hyphema</td>
<td>None</td>
<td>20/60</td>
<td>20/35</td>
<td></td>
</tr>
</tbody>
</table>

Abbreviations: AION, anterior ischemic optic neuropathy; ARMD, age-related macular degeneration; CF, counting fingers; ECCE, extracapsular cataract extraction; LP, light perception; mo, months; PC-IOL, posterior chamber intraocular lens; s/p, status post.
The final best-corrected visual acuity ranged between 20/40 and 20/20 unless a preoperative abnormality was present. Poor visual acuity (2 cases, 22%) was associated with macular injury (P = .03). One patient had a macular scar with visual acuity of counting fingers at 2.1 m and the other developed macular scar and epiretinal membrane with final visual acuity of counting fingers at 3.0 m.

**COMMENT**

Because most practitioners in ophthalmology perform anterior segment procedures, intraocular injury caused by irrigation or viscoelastic cannula is an important public health concern. At our institute, 2 (13%) of the 15 ophthalmic residents and 2 (40%) of the 5 attending physicians in a period of 15 years have experienced inadvertent release of a cannula during anterior segment surgery and all remembered it for years as a stressful event. However, it was found to occur in only 0.07% of cataract extractions, 0.2% of the penetrating keratoplasties and triple procedures, and none of the 422 filtration procedures in 15 years, making this a rare event of 0.88 per 1000 procedures per year.

We are unaware of any epidemiologic study or case series on inadvertent cannula release during ocular surgery. To the best of our knowledge, only 2 cases have been described in the literature in which accidental cannula release occurred during phacoemulsification, causing posterior capsule rupture, vitreous loss, and vitreous hemorrhage. In 1 of them a retinal break was found and treated with laser retinopexy. Both cases had no permanent ocular damage and the final visual acuity was 20/20 after the vitreous hemorrhage was resolved, because the injury probably spared the macula.

The accidental release of a cannula during anterior segment surgery may be attributed to 3 main factors. The first factor is insecure attachment of the cannula to the syringe. The second factor is the forceful injection of the agent into the eye. The third factor involves the instrument, including the viscosity of the injected agent, the ratio of the diameter and length of the cannula/syringe, and the patency of the cannula. The resistance to flow as determined by the Bernoulli law is directly proportional to the length and inversely proportional to the diameter of the cannula, which should be designed according to the standards of the American Society of Mechanical Engineering. The cannula may be blocked if the viscoelastic material is left unwashed. If the cannula is blocked, the force within it will be much higher than in a patent one and pressure will be released at the weakest point, the point at which the large-diameter syringe is attached to the small-diameter cannula. The resistance is also proportional to the viscosity of the injected material. Some of the viscoelastic agents are highly viscous (eg, Healon GV and Healon 5; Advanced Medical Optics, Santa Ana, California) and the force required to insert them may be considerably high. Viscoelastic cannulas would be expected to have a greater tendency to be released because of higher release speed resulting from the higher viscosity and tendency to block the cannula.

In our study, we found that the release of viscoelastic cannulas had marginally higher potential for retinal injuries (2 of 3) than irrigation cannulas (0 of 6, \( P = .182 \)). With larger samples, this difference may become statistically significant.

In theory, intraocular release of cannulas may occur at any stage of the surgery when cannulas are being used. Although we found a tendency for cannulas to be released during filling of the anterior chamber with viscoelastic material and hydration of the paracenteses, the number of cases is too limited to make a conclusion.

Forceful release of cannulas usually causes major impact in the direction in which the cannula is aimed. Secondary and lesser impact may result from deviation of the cannula after the first striking of one of the solid structures of the eye. Cannulas may injure the corneal endothelium, the anterior chamber angle, the iris and its major arterial circle, the intraocular lens, the posterior capsule, and the retina. In our series, the cannulas injured the cornea, the iris, the angle, the posterior capsule, and the retina. Injury may cause localized corneal edema; hyphema; iris tear; vitreous loss and vitreous hemorrhage; and retinal contusion, break, and detachment. Vitreous loss, retinal contusion, and late development of epiretinal membrane occurred in our series. Although macular involvement by direct contusion or indirectly because of retinal detachment may result in poor visual outcome, the visual prognosis of such trauma is otherwise good.

In 4 (67%) of 6 cases of cannula release during cataract surgery, only anterior segment structures were injured. In all 4 cases, cannulas were inadvertently released during hydration of the paracentesis. Cannula release during penetrating keratoplasty was statistically associated with posterior segment involvement, and macular injury was statistically associated with poor visual outcome. The possible difference in the ocular structures damaged may be related to the course of the released cannula, which, in turn, is probably related to the structure of the surgical wound. The surgical incisions in cataract surgery are directed horizontally toward the anterior chamber, while in penetrating keratoplasty and triple procedures, the entire anterior chamber is open and the opening is facing the posterior segment. We have not encountered cases of cannula release during filtration procedures probably because of a smaller number of these procedures and possibly because of less frequent use of cannulas during these procedures.

Prevention of intraocular injuries is the best treatment and eye surgeons should be aware of such injuries and the means to prevent them. Each cannula should be used according to the manufacturer’s instructions. The cannula should be secured to the syringe by the assistant or the nurse and by the surgeon for double assurance. The surgeon must personally secure all surgical instruments, including cannulas, phaco tips, and intraocular lens injectors, before inserting them into the patient’s eye. When injecting a highly viscous agent, the surgeon may hold the base of the cannula to prevent its release into the eye during injection. If the injected material is highly viscous, the diameter of the cannula is too small, or its length is too long, a forceful injection may be sufficient.
to release the cannula. Therefore, it is imperative to use the proper instruments according to the manufacturer’s instructions; it is recommended that syringes be used with lockers (eg, Luer-Lok syringe) when injecting a highly viscous agent. The surgeon should attempt injection outside the eye to ensure security of the cannula and its patency. Injection should be slow and gentle. The tip of the cannula should be pointed toward the angle in anterior chamber filling, toward the ciliary processes in posterior chamber filling, and toward the pars plana in capsular bag filling. The tip should never be directed at the posterior capsule facing the posterior segment. After the injection of viscoelastic material, the cannula should be immediately washed with balanced salt solution to prevent its occlusion. We used these prevention measures during the study but still encountered inadvertent cannula release.

If ocular complications occur because of forceful cannula release, they should be treated promptly. Piercing the posterior capsule with loss of vitreous requires anterior vitrectomy and meticulous search for retinal break by indirect ophthalmoscopy during surgery. If a retinal break is found, it should be treated immediately with laser barrage. Retinal detachments, if any, should be treated promptly by a vitreoretinal specialist. In the case of vitreous hemorrhage, retinal break and detachment should be ruled out. Vitrectomy allows the affected retina to be visualized, and retinal breaks may be treated with argon laser photocoagulation.

In conclusion, the accidental release of cannulas during anterior segment surgery is a rare iatrogenic intra-operative complication that may cause serious sight-threatening intraocular injury. Ocular surgeons should recognize this potential complication and know how to prevent its occurrence.

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REFERENCES