Errors in Strabismus Surgery

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Objectives: To determine the prevalence of and contributing factors for errors in strabismus surgery.

Methods: Five hundred seventeen of 1103 strabismus surgeons (46.87%) completed a survey administered during the 2011 American Association for Pediatric Ophthalmology and Strabismus national meeting or e-mailed to members of the association.

Results: One hundred seventy-three strabismus surgeons (33.5%) self-reported having operated on the wrong eye or muscle or performed the wrong procedure at least once. The mean error rate was 1 in 2506 (95% CI, 2128-2941) operations. Surgeons who performed fewer than the median 1500 procedures had an error rate 5.9 (95% CI, 4.1-8.2) times higher than surgeons who performed more than the median (P < .001). The most common factors contributing to errors were confusion between the type of deviation (esotropia/exotropia) and/or the sur-
gical procedure (recession/resection) (34 of 114 responses [29.8%]), globe torsion (20 [17.5%]) leading primarily to inadvertent operation on the inferior rectus rather than the intended medial rectus muscle, and in-
attention and/or distraction (19 [16.7%]). Running more than 1 operating room (P = .02) and failing to mark eye muscles preoperatively (P = .03) were associated with an increased likelihood of error.

Conclusions: Self-reported error in strabismus surgery is a complication approximately as common as peri-
obital cellulitis. Reducing error in strabismus surgery might entail confirming that the deviation matches the surgical plan preoperatively, more elaborate site marking, and involving an assistant in a preoperative verification of the specific eye muscles and surgical procedure.

We defined an error in strabismus surgery as operating on the wrong eye or muscle or performing the wrong procedure for the patient’s underlying ocular deviation. The self-reported error rate was calculated as the number of errors divided by the number of lifetime strabismus operations reported by all surgeons. We also calculated this rate for individual surgeons. We compared the individual surgeon error rate between surgeons who had performed fewer than the median number of procedures (inexperienced surgeons) and those who had performed greater than the median (experienced surgeons) using the Wilcoxon rank sum test with continuity correction.

Errors were categorized as the wrong eye, the wrong extraocular muscle, the wrong procedure (such as resection instead of recession), or the wrong patient. For all errors that were adequately described by reporting surgeons, we classified contributing factors that may have led to the error.

We investigated whether the daily caseload or the running of multiple operating rooms might influence the likelihood of error by performing a multivariate logistic regression in which we controlled for lifetime surgical volume. We used the Fisher exact test to compare error-prevention strategies between surgeons who had experienced an error during their careers and those who had not. For all potential predictors of error in strabismus surgery found to be statistically significant (P < .05), we explored whether the statistical significance withstood the Holm test of multiple comparisons. Statistical analyses were performed using the R statistical package (http://www.r-project.org).

**RESULTS**

Surveys were completed by 517 of 1103 surgeons (211 during the American Association for Pediatric Ophthalmology and Strabismus meeting and 306 online), for a response rate of 46.87%. One hundred seventy-three respondents (33.5%) reported an error made during their training or as an attending surgeon. Of the 152 surgeons who reported having made an error as an attending surgeon, 98 (64.5%) reported 1 error; 27 (17.8%), 2 errors; and 3 (2.0%), 3 errors during their careers. Twenty-four surgeons (15.8%) did not answer the question.

**ERROR RATE**

The error rate in strabismus surgery was 1 error for every 2506 (95% CI, 2128-2941) cases. The mean error rate for individual surgeons was 1 in 909 (95% CI, 714-1316) cases. The median error rate for individual surgeons was 1 in 2326 cases, with an upper quartile of 1 in 769 cases and a lower quartile of 1 in 4000 cases. The median number of reported strabismus procedures performed in a surgeon’s career was 1500. Inexperienced surgeons were 5.9 (95% CI, 4.1-8.2) times more likely to experience an error than experienced surgeons (inexperienced surgeon error rate of 1 in 476 [357-714] cases vs experienced surgeon error rate of 1 in 2778 [2439-3226] cases; P < .001).

**TYPES OF ERRORS AND CONTRIBUTING FACTORS**

The 173 errors consisted of 61 wrong procedures (35.3%), 38 wrong muscles (22.0%), 16 wrong eyes (9.2%), 4 wrong patients (2.3%), 11 miscellaneous (6.4%), and 43 unspecified errors (24.9%). Of the 173 respondents, 114 described factors that may have contributed to the error. The most common contributing factors were confusion between the type of deviation and/or surgical procedure (34 errors [29.8%]), globe torsion or anatomical difficulties (20 [17.5%]), and inattention and/or distraction (19 [16.7%]). Table 1 describes the contributing factors by

<table>
<thead>
<tr>
<th>Table 1. The Most Common Self-reported Contributing Factors Leading to Error in Strabismus Surgery</th>
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<tbody>
<tr>
<td>Factor</td>
</tr>
<tr>
<td>Wrong procedure (n = 54)</td>
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<tr>
<td>Esotropia/exotropia or recession/resection confusion</td>
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<tr>
<td>Hypertropia/hypotropia confusion</td>
</tr>
<tr>
<td>Inattention and/or distraction</td>
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<tr>
<td>Following preset pattern</td>
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<tr>
<td>Kestenbaum-Anderson confusion</td>
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<tr>
<td>Wrong preoperative plan</td>
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<tr>
<td>Wrong muscle (n = 32)</td>
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<tr>
<td>Ocular torsion</td>
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<tr>
<td>Scarring, reoperation, or bleeding</td>
</tr>
<tr>
<td>Inattention and/or distraction</td>
</tr>
<tr>
<td>Wrong eye (n = 15)</td>
</tr>
<tr>
<td>No time-out</td>
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<tr>
<td>Lack of site marking or incorrect draping</td>
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<tr>
<td>Hypertropia/hypotropia confusion</td>
</tr>
<tr>
<td>Inattention and/or distraction</td>
</tr>
<tr>
<td>Wrong preoperative plan</td>
</tr>
<tr>
<td>Following preset pattern</td>
</tr>
<tr>
<td>Wrong patient (n = 4)</td>
</tr>
<tr>
<td>Wrong medical record consulted</td>
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<tr>
<td>Similar patient names</td>
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<tr>
<td>Change to surgical schedule resulting in a new order of patients</td>
</tr>
<tr>
<td>Sequential patients with similar deviations; order of patients confused</td>
</tr>
<tr>
<td>Miscellaneous (n = 9)</td>
</tr>
<tr>
<td>Inattention and/or distraction</td>
</tr>
<tr>
<td>New assistant</td>
</tr>
<tr>
<td>Following preset pattern</td>
</tr>
</tbody>
</table>

*More than 1 contributing factor could be attributed to each error case; thus, total percentages exceed 100. | Definition as eye muscle surgical procedure performed in the direction opposite that needed to correct an anomalous head posture. |

Includes repetition of a procedure performed previously on the same patient; order of patients confused.
error subtype. Sixteen of the 114 respondents (14.0%) reported a combination of factors contributing to the error. The inferior rectus muscle was the most common “wrong muscle” (20 of 32 cases described in sufficient detail [62.5%]). In 16 of these cases, the surgeons described inadvertent inferior rectus surgery rather than intended medial rectus surgery.

Surgeons reported when the error was detected and corrected and who assisted in the case that resulted in surgical error. Results are shown in the eTable.

**TIME-OUT**

When asked if the surgeon had performed a time-out before the case that resulted in an error, 86 (49.7%) of the 173 respondents reported not having performed a time-out, 53 (30.6%) did perform a time-out, and 34 (19.7%) did not answer the question. A time-out had been performed but failed to prevent an error in 22 (36.7%) of 60 wrong procedures, 17 (48.6%) of 35 cases involving the wrong muscle, 4 (30.8%) of 13 involving the wrong eye, and 2 (50.0%) of 4 involving the wrong patient. Errors that could not be classified were not counted in this calculation.

**SURGICAL VOLUME**

Most respondents (216 [45.8%]) performed 4 to 5 cases daily; few (13 [2.8%]) performed more than 10 cases daily. Twenty respondents (4.2%) ran 2 or more operating rooms simultaneously. In a multivariate analysis controlling for lifetime surgical volume, daily caseload was not a significant predictor of error (P = .13), but surgeons who ran multiple operating rooms had a higher likelihood of reporting an error than surgeons who ran only 1 (P = .02; P = .06 after correcting for multiple comparisons).

**PREVENTIVE MEASURES**

Table 2 compares preventive practices of surgeons who reported and did not report errors. Only marking eye muscles before surgery was associated with a decreased likelihood of error (odds ratio, 0.63 [95% CI, 0.41-0.97]; P = .03; P = .07 after correcting for multiple comparisons).

**COMMENT**

**PREVALENCE OF HUMAN ERROR IN STRABISMUS SURGERY**

We anonymously surveyed 517 strabismus surgeons to estimate the prevalence of self-reported errors in strabismus surgery. One-third of strabismus surgeons reported a surgical error during their careers, some as many as 3 times. In comparison, 21% of orthopedic hand surgeons had operated on the wrong site,15 and 32% of neurosurgeons had removed lumbar disc material from the wrong spinal level.16 We found an error rate of 4.0 per 10,000 strabismus procedures, which falls in the upper range of 0.09 to 4.5 per 10,000 cases for wrong-site surgery across all surgical fields.17 We estimated the rates of other complications of strabismus surgery from the literature. The prevalence of scleral perforations is 30 to 280 per 10,000 strabismus cases;18-21 periorbital/orbital cellulitis, 5 per 10,000 cases;22-24 retinal detachment, 0.05 per 10,000 cases;25-27 endophthalmitis, 0.05 per 10,000 cases.28,29 Retinal detachment after strabismus surgery has been described only in case reports.30,31 Thus, self-reported human error is less common than scleral perforation, is as common as periorbital/orbital cellulitis, and is more common than endophthalmitis and retinal detachment.

**FACTORS CONTRIBUTING TO ERROR IN STRABISMUS SURGERY**

We qualitatively and quantitatively studied factors leading to error in strabismus surgery. Common contributing factors included (1) confusion between recession and resection, esotropia and exotropia, and hypertropia and hypotropia; (2) globe torsion and anatomical difficulties; (3) inattention and/or distraction; (4) following a preset pattern (a surgeon who performs 5 esotropia resection, exotropia and hypertropia, and hypertropia and hypotropia); (5) time-out omissions; (6) consulting the wrong medical record; (7) lack of site marking and inappropriate draping; (8) Kestenbaum-Anderson confusion (ie, an eye muscle surgical procedure performed in the direction opposite that needed to correct an anomalous head posture); and (9) working with new assistants. Some surgeons described multiple factors contributing to error (eg, 1 case involved visiting a regional hospital 950 miles away, late arrival to the operating room, an angry parent, an unskilled and upset surgical team, and no time-out).

Wrong procedures constituted the greatest proportion of error cases. Most of the wrong procedures were due to confusion of horizontal muscle recession and resection and/or esotropia and exotropia (63%), which is

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**Table 2. Preventive Measures Taken to Reduce Likelihood of Error**

<table>
<thead>
<tr>
<th>Preventive Measure</th>
<th>Reporting Error (n = 143)</th>
<th>Reporting No Error (n = 329)</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Examine patient preoperatively on the same day as operation to confirm deviation</td>
<td>67 (46.9)</td>
<td>150 (45.6)</td>
<td>.84</td>
</tr>
<tr>
<td>Mark the eye muscles and procedure to be performed on the patient’s face or on the drape</td>
<td>85 (59.4)</td>
<td>230 (69.9)</td>
<td>.03</td>
</tr>
<tr>
<td>Discuss the surgical plan with an assistant surgeon</td>
<td>76 (53.1)</td>
<td>170 (51.7)</td>
<td>.84</td>
</tr>
<tr>
<td>Post the preoperative examination results where they are visible to the surgeon in the operating room</td>
<td>79 (55.2)</td>
<td>180 (54.7)</td>
<td>.92</td>
</tr>
<tr>
<td>Post the surgical plan where it is visible during the operation</td>
<td>100 (69.9)</td>
<td>233 (70.8)</td>
<td>.91</td>
</tr>
</tbody>
</table>

*Surgeons could select more than 1 preventive measure on the survey; thus, total percentages could exceed 100. Forty-five of 517 respondents did not answer the specific question.*
not surprising because these terms represent the most common types of strabismus procedures. Confusion of recession and resection is not equally problematic; a recession can easily be converted to a resection, but an inadvertent resection converted to a recession may result in muscle tightening that limits ocular rotations.

Operating on the wrong muscle was the second most common error subtype (22.0%) and occurred most often because of globe torsion (63%). Surgeons often described haste and unrecognized globe rotation by the assistant as factors leading to inadvertent operations on the inferior rectus rather than the medial rectus muscle. Unusual anatomy was a rare cause of operating on the wrong muscle. Patients may have torsional rotation of the orbits and extraocular muscles that the surgeon does not recognize preoperatively, or they may have unusual locations of the extraocular muscles owing to prior procedures and scarring. Disinsertion of the incorrect muscle may disrupt the anterior-segment blood supply.

In our exploration of the effects of surgical experience and surgical volume on error in strabismus surgery, we found that inexperienced surgeons had an error rate 5.9 (95% CI, 4.1-8.2) times higher than experienced surgeons (P < .001). Surgeons who experience an error early in their careers likely make changes to their surgical practices to prevent future errors. Performing a large number of cases each day was not associated with an increased likelihood of error, but running more than 1 operating room was (P = .02; P = .06 correcting for multiple comparisons).

PREVENTION OF HUMAN ERROR IN STRABISMUS SURGERY

We found that, in 53 of 139 surgical error cases (38.1%), a time-out had been performed but failed to prevent an error. The time-out, as commonly performed under the Universal Protocol, focuses on laterality and the type of procedure to be performed; for example, the surgeon might say, “Time-out, strabismus surgery, both eyes.” The time-out does not involve verification that a recession vs a resection is appropriate to treat the underlying deviation. Confusing recession and resection would be more devastating than operating on the wrong eye for a patient undergoing a unilateral medial rectus resection and lateral rectus recession for intermittent exotropia. Based on the quantitative and qualitative survey data analyses, we suggest that strabismus surgeons consider some modifications to the Universal Protocol (Figure).

Preoperative Verification

In addition to the standard preoperative verification, the surgeon should repeat an ocular alignment test to verify that the deviation matches that described in the medical record and confirm that the surgical plan correctly addresses the deviation. Although few surgeons operate with assistants knowledgeable in strabismus, when possible, an assistant should repeat these steps. The patient and caregivers should be involved in the preoperative verification process within the constraints of understanding strabismus.

Site Marking

We found that surgeons who marked eye muscles were less likely to experience error than those who did not (P = .03; P = .07 after correcting for multiple comparisons). Because recession and resection and the abbreviations rec and res can easily be mistranscribed and confused, using alternative terms may be more appropriate. We suggest that the surgeon place skin marks corresponding to the location of specific eye muscles rather than just marking the operative eye. The surgeon could place W for weakening and S for strengthening next to these marks. Site markings should remain visible after the patient is prepped and draped and likely should be placed after anesthesia induction for children who are fearful of marks being placed near the eyes.

Most errors involving wrong muscles were inadvertent isolations of inferior rectus rather than medial rectus muscle. Thus, when performing medial rectus operations, marking the nasal limbus with a dot can allow the surgeon and assistant to maintain appropriate orientation before beginning manipulations that induce torsion.

Time-out

The strabismus surgery time-out should include the deviation, the specific muscles to undergo operation, and the intended procedure (ie, “weakening both medial rectus muscles for esotropia” rather than “strabismus surgery, both eyes”). This recommendation is analogous to the American Academy of Ophthalmology Wrong-Site Task Force advocating the verification of IOL type and power—in addition to verifying the correct eye—to address wrong IOL implantations. The surgeon and staff should recognize potential causes of error, including following a preset pattern, distraction, a new assistant, running multiple operating rooms, etc.

LIMITATIONS

Data were collected from an opt-in survey subject to selection bias of respondents. Reporting of errors, descriptions of errors, and lifetime surgical volume were subject to recall bias. The self-reported surgical error rate could underestimate or overestimate the true rate. Al-
though we ensured anonymity to survey respondents, concerns regarding professional reputation or liability may have led to underreporting of errors. Alternatively, surgeons who had experienced error may have been more likely to participate owing to interest in the subject.

Most strabismus surgeons in the United States had the opportunity to participate in the survey, and we had a response rate of 46.87%. Because no mandatory or standardized reporting of strabismus surgery errors exists, our survey data from 517 surgeons’ self-reports are currently the best available on this topic. Simon et al10 analyzed data from Ophthalmic Mutual Insurance Company malpractice claims and from the New York Patient Occurrence Reporting and Tracking System and found only 1 strabismus case of 106 ophthalmic cases involving surgical confusion. Patients treated for strabismus often undergo reoperations. Thus, unlike lens exchanges, which are not expected after cataract surgery, reoperations for strabismus surgery errors could easily be underreported.

Our strabismus-specific modifications to the Universal Protocol have not been prospectively evaluated as a means of reducing error. In the absence of mandated reporting of errors and the relative rarity of such complications, executing a prospective trial to evaluate a strabismus-specific Universal Protocol would be challenging. However, in a prospective trial involving 2,826,367 operations in 8 hospitals worldwide, Kwaan and colleagues2 showed that implementing a specific checklist for general surgery decreased mortality and surgical complications by 36%. Regimen adherence to protocols or checklists should not impair the surgeon’s flexibility in making intraoperative decisions. Rather, strabismus surgeons should adapt error-prevention strategies to their varied practice situations. Empowering assistants to participate in the preoperative verification and in the time-out and to verify correct muscle isolation and correct procedure intraoperatively would take the onus off of the surgeon as the sole member of the surgical team responsible for these critical steps.30

In conclusion, our study found a self-reported error rate of 1 in 2506 strabismus cases. Most of the errors were confusion of resection and resection of and esotropia and exotropia. Site marking (ie, specific eye muscles, not just the eye) was associated with a decreased likelihood of error. Surgeon inexperience and running multiple operating rooms were associated with an increased likelihood of error. Considering the results of this study, we suggest that strabismus surgeons consider modifying the Universal Protocol to address their subspecialty-specific causes of error better.

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Online-Only Material: The eTable and eFigure are available at http://www.jamaophthalmology.com.

REFERENCES