POST-OPERATIVE VISUAL LOSS
A Preventable Complication?

Daniel J. Janik, MD
Associate Professor
University of Colorado Denver

Overview
• General incidence of eye injuries
• Visual loss – incidence
• Types of visual loss
• Risk factors
• Strategies for prevention
• ASA recommendations

Eye Injury Associated with Anesthesia
• Eye injury accounts for 3-8% of anesthesia-related malpractice claims
• General anesthesia 83%
• Monitored anesthesia care 11%
• Conduction blockade 7%
• Incidence of corneal abrasion:
  Roth 1996 – 0.034% (non-ophthalmic surgery)
  Cucchiara 1988 – 0.17% (neurosurgical, mostly prone)

Eye Injury Associated with Anesthesia
• 30% of claims were for eye injury associated with movement during eye surgery
  Blindness was outcome in all cases
  Median payment high ($90,000)
• If you do eye blocks:
  You will have a significantly altered risk profile related to permanent eye damage from eye block needles than if you only provide MAC (48 vs. 3 in claims study)

Post-operative Visual Loss
Roth S et al, Anesthesiology 1996; 85:1020-7
• 60,965 anesthetics from 1988-1992
• Non-ocular surgery
• 34 Patients (0.056%) with eye injury, 2 patients (0.003%) with visual loss
• Only 21% of all cases had discernible cause

DISCLOSURE
I have no commercial or other conflicts of interest
Post-operative Visual Loss
Roth S et al, Anesthesiology 1996; 85:1020-7

- Independent Risk Factors:
  Length of surgery
  Lateral positioning
  Operations on head or neck
  General anesthesia
  Surgery on Monday

Post-operative Visual Loss
Warner ME, Anesthesia & Analgesia 2001; 93: 1417-21

- 501,342 anesthetics from 1986-1998
- 405 cases of visual loss
- 216 regained full vision within 30 days
- 189 lost vision > 30 days
  185 underwent ophthalmologic/neurosurgical procedure with tissue damage or loss
  4 without tissue damage/loss = 0.0008%

Post-operative Visual Loss
Warner ME, Anesthesia & Analgesia 2001; 93: 1417-21

- None of 26,212 neuraxial blockade patients had visual loss
- None of 11,942 spinal surgery patients had loss > 30 days  (8 had loss < 30 days)
- Data contrasts with 0.06% loss after cardiac surgery (Nuttall, 2001)

Post-operative Visual Loss
Nuttall GA et al, Anesthesia and Analgesia 2001; 93:1410-6

- Study of 27,915 patients undergoing CPB
- 17 had ION; 0.06% (12 AION, 5 PION)
- Bivariate risk factors:
  Low Hgb conc (<8.5 g/dL)
  Atherosclerotic vascular disease
  Pre-operative angiogram
- Univariate risk factors
  RBC transfusions (OR 1.3)
  Any non-RBC product (OR 4.4)

Post-operative Visual Loss

- Retrospective study using National Inpatient Sample data from 1993 to 2003 undergoing spine surgery:
  4,728,815 patients total
  4134 (0.087%) had postoperative visual sx
  271 (0.006%) had diagnosis of ION
  47 (0.001%) had diagnosis of CRAO
  Overall incidence was 0.094%
Post-operative Visual Loss

- Highest incidence:
  - Surgery for scoliosis – 0.28%
  - Posterior-only approach – 0.29%
  - Anterior-only approach – 0.17%

- Risk factors for non-ION, non-CRAO loss:
  - Age<18 years: OR 5.8
  - Age>84 years: OR 3.2
  - Peripheral vascular disease: OR 2.0
  - Pre-existing hypertension: OR 1.3
  - Blood transfusion: OR 2.2

Post-operative Visual Loss
Shen Y and Roth S, Anesthesiology 2008; 109: A1013

- Retrospective study using National Inpatient Sample from 1996 to 2005

- Rates of visual loss:
  - Spinal fusion – 1:3364 (0.029%)
  - Laminectomy – 1:11,453 (0.0087%)
  - Appendectomy – 1:78705 (0.0012%)

- Spinal fusion with visual loss:
  - 57% lumbar/lumbosacral
  - 35% thoracic/thoracolumbar
  - 8% cervical

Post-operative Visual Loss

- 126,666 operations from 1998-2004
- Retrospective chart review and case-control study
- Non-ocular surgery; ION only
- 17 cases (0.013% overall incidence)
  - CABG – 0.33%
  - Spine – 0.36%
  - Other – 0.003%
- 16/17 were MALE (more on that later)

Post-operative Visual Loss
Shen Y and Roth S, Anesthesiology 2008; 109: A1013

- Spinal fusion with visual loss:
  - **83% posterior approach**
  - Male vs. female similar
  - Younger
  - Similar co-morbidities to patients without loss

Summary of Studies Reporting Incidence

<table>
<thead>
<tr>
<th>Year</th>
<th>Population</th>
<th>Incidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Roth, Thistead, et al 1996</td>
<td>General Surgical</td>
<td>0.003%</td>
</tr>
<tr>
<td>Warner, Warner, et al 2001</td>
<td>General Surgical</td>
<td>0.001%</td>
</tr>
<tr>
<td>Nuttall, Garrity, et al 2001</td>
<td>Cardiac</td>
<td>0.060%</td>
</tr>
<tr>
<td>Kalyani, Miller, et al 2004</td>
<td>Cardiac</td>
<td>0.113%</td>
</tr>
<tr>
<td>Stevens, Kelley, et al 1997</td>
<td>Spine</td>
<td>0.200%</td>
</tr>
<tr>
<td>Chang, Miller 2005</td>
<td>Spine</td>
<td>0.028%</td>
</tr>
<tr>
<td>Patil, Lad, et al 2008</td>
<td>Spine</td>
<td>0.094%</td>
</tr>
<tr>
<td>Shen, et al 2009</td>
<td>Spine</td>
<td>0.01%</td>
</tr>
</tbody>
</table>
Most Common Causes

- Ischemic Optic Neuropathy (ION)
- Central Retinal Artery Occlusion (CRAO)
- Cortical Blindness
- Central Retinal Vein Occlusion

Cortical Blindness

- Caused by damage to the optic radiation or occipital cortex (resulting in infarction) from:
  - Embolism (particulate or air)
  - Sustained hypotension
  - Cardiac arrest
- Presentation:
  - Painless loss of vision, pattern depends on area affected

Central Retinal Artery Occlusion

- Usually caused by compression of the eye leading to increased intraocular pressure with resultant decrease or cessation of flow in the central retinal artery
- End result is retinal ischemia due to lack of oxygen delivery

Cortical Blindness

- Physical findings:
  - Normal optic disk
  - Retention of pupillary reflex
  - Abnormal CT or MRI
- Prognosis:
  - Good
- Treatment:
  - Maintain Hgb and normal cerebral perfusion pressure to avoid extending damage
  - Hyperbaric O₂ if air embolism is suspected

Anatomic Classification of Visual Loss

Williams EL et al; Anesth Analg 1995; 80:1018-29

- AION: Anterior ischemic optic neuropathy
- PION: Posterior ischemic optic neuropathy

Non-hemorrhagic infarct in left occipital lobe

Central Retinal Artery Occlusion

- Presentation:
  Symptom onset within 24 hours
  Unilateral visual loss
  No light perception

- Physical findings:
  Afferent pupil defect
  Periorbital edema or other trauma
  Cherry red spot on fundoscopic exam

Central Retinal Artery Occlusion

Roth S. ASA Refresher Course Lectures 2008

- Prognosis:
  Usually irreversible

- Treatment:
  No consistently effective treatment
  Acetazolamide and inhalation of 5% CO2?

- Etiology:
  Emboli
  Improper positioning
  External compression (head and neck surgery)

Ischemic Optic Neuropathy

- Anterior ischemic optic neuropathy (AION)
  - Non-arteritic (more common perioperative type)
  - Arteritic

- Posterior ischemic optic neuropathy (PION)

Vascular Supply of Anterior Optic Nerve

Williams EL et al; Anesth Analg 1995; 80:1018-29

Anterior Ischemic Optic Neuropathy

- Caused by transient decrease in perfusion pressure of the nutrient vessels of the anterior optic nerve below autoregulatory range
  - Decreased mean arterial pressure
  - Increased intraocular pressure
  - Both

- Injury depends on severity and duration of transient ischemia

Anterior Ischemic Optic Neuropathy

- Presentation:
  Painless visual loss
  Usually in first 24-48 hours after surgery
  Afferent pupil defect or unreactive pupils
  Usually noted upon awakening
  Visual field deficits (inferior) or complete loss
  Commonly bilateral, but may be unilateral
Anterior Ischemic Optic Neuropathy

- Physical Findings:
  - Early optic disk edema
  - Optic disk hemorrhages
  - Disk edema replaced by pallor in 2-3 months
- Prognosis:
  - Poor - <30% show some improvement
- Treatment:
  - None

Ischemic Optic Neuropathy – Visual Field Deficit

American Society of Anesthesiologists, Postoperative Visual Loss Registry

Posterior Ischemic Optic Neuropathy

- Caused by decreased oxygen delivery to posterior portion of optic nerve (between optic foramen and where central retinal artery enters nerve)
- Nerve only fed by pial vessels which are sensitive to compression
- Not usually associated with occlusive vascular disease
- More likely to be associated with emboli than AION

Vascular Supply of the Eye

Baig 2007

Posterior Ischemic Optic Neuropathy

- Presentation:
  - Similar to AION, but may also develop slower
- Physical findings:
  - Optic disk appears normal early
  - Mild disk edema days later
  - Orbital CT may show enlarged intraorbital optic nerve
Posterior Ischemic Optic Neuropathy

- Prognosis:
  Poor – like AION, usually fixed deficit
- Treatment:
  None

Posterior Ischemic Optic Neuropathy – Etiology

Williams EL. Anesthesiology Clin N Am 2002; 20:367-384

- Multifactorial:
  Hypotension*
  Low Hemoglobin*
  Increased intraorbital venous pressure
  Infection
  Venous obstruction*
  Congenital absence of central retinal artery
  Internal carotid artery dissection

Posterior Ischemic Optic Neuropathy – Risk Factors


- 7 Institutional cases plus literature search
- Male
- Mean age 50 years old
- Spine surgery
- Intraoperative hypotension
- Large blood loss (2000-16,000ml)
- Drop in hematocrit of 9.5-19% (mean 14%)
- Facial swelling

Fundoscopy

Normal Papilledema
Atrophied Disc
Cherry Red Spot

Post-operative Visual Loss Anatomic Considerations

- Blood supply to optic nerve is vulnerable
- Known variability in blood supply
- Atypical anatomic patterns
- Poor watershed perfusion zones
- Abnormal autoregulation
- Optimal range of hematocrit and blood pressure for adequate O2 delivery to optic nerve unknown (particularly in presence of venous congestion in prone position)

ASA POVL Registry

- Established by ASA in June 1999
- Goal is to obtain sufficient cases (100 or more) so associations can be made and investigated
- Presently have 195 cases reported as of February 2013
- 131 cases (67%) are spine surgery
- 16 cardiac cases
- 6 prostate cases (3 robotic, 3 open)
- 12 orthopedic, 2 liver transplants, 3 aortas
Most Common Procedures

- Spine surgery (67%)
- Cardiac surgery (8%)
- Liver transplant
- Thoraco- and abdominal aneurysms
- Head and Neck surgery
- Thoracotomy
- Others

Post-operative Visual Loss


- Most patients middle-aged (median=49)
- Long duration (median=8 hours)
- Blood pressure decreases (median=37% drop; deliberate hypotension used in 40% of cases)
- Large blood loss (median=2.3L)
- Anemia (median hematocrit=25%)
- Intraoperative course may be completely unremarkable
- 18% of patients were in Mayfield holder (ION can occur without pressure on eye)

Anesthesia Duration in Spine ION Cases (n=83)

Estimated Blood Loss in Spine Cases with ION (n=83)

Post-operative Visual Loss

Lee LA et al, Anesthesiology 2006; 105(4): 652-659

- Occurs over a wide range of reported blood pressures

Post-operative Visual Loss

Lee LA et al, Anesthesiology 2006; 105(4): 652-659

<table>
<thead>
<tr>
<th>Type of surgical frame or table</th>
<th>No. (%)</th>
<th>Type of headrest</th>
<th>No. (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>None (control)</td>
<td>25 (50)</td>
<td>Foam pad</td>
<td>47 (95)</td>
</tr>
<tr>
<td>Mayfield frame</td>
<td>5 (10)</td>
<td>Donut type pad</td>
<td>10 (20)</td>
</tr>
<tr>
<td>Other (unknown)</td>
<td>13 (26)</td>
<td>Other/Dont know</td>
<td>13 (26)</td>
</tr>
</tbody>
</table>

Table 4. ASS F305 Registry: Type of Surgical Frames, Tables, and Headrests in Spine Cases with ION (n = 83)
Most patients had one or more co-existing disease, but can happen in ASA Class 1 patients also

Interesting Points:
- Most patients with CRAO had evidence of ocular trauma and unilateral vision loss which suggests positioning may be at fault
- Most patients with ION had bilateral visual loss indicating systemic or patient-specific factors may play role

Summary of Suggested Risk Factors:
- Hypertension
- Diabetes
- Smoking
- Atherosclerosis
- Male gender
- Middle age
- Spine surgery
- Head and neck surgery
- Cardiac surgery
- Hyperlipidemia
- Intraoperative hypotension
- Intraoperative anemia
- Large blood loss
- Large fluid resuscitation
- Facial edema
- Prone position – head down
- Prolonged surgical time
- Eye trauma
- Vasopressors

None of these were significant!
Hypotension and Post-operative Ischemic Optic Neuropathy

- 80 adults in POVL registry matched with 315 control patients for year of surgery
- Independent risk factors:
  - Anesthesia duration (OR/1 hr 1.39) Obesity (OR 2.83)
  - Wilson frame use (OR 4.3) Male Sex (OR 2.53)
  - Lower colloid use (OR/5% 0.67) EBL (OR/1L 1.34)
- No independent effect:
  - Any BP > 40% below baseline for 30 min
  - Anemia

POVL Study Group, Anesthesiology 2012, 116:15-24

Proposed Theories of Origin of Ischemic Optic Neuropathy

- Etiology of ION may be influenced more by intraoperative physiologic perturbations than pre-existing disease states
- Higher proportion of men to women (69%) suggests protective effect of estrogen
- Acute venous congestion of optic canal suggested by risk factors: Obesity, Wilson frame, long duration, EBL, % colloid (and cases of ION occurring in neck dissections and robotic prostatectomies)
- Role of systemic inflammatory response?

So, What Should I Do To Protect My Patient (and Myself)?

- Proper positioning:
  - Prone position with head down will cause increase in intraocular pressure and favor development of periorbital edema
  - Keep head above level of heart
  - Use padded headrest without pressure on eyes

Post-operative Visual Loss: Strategies for Prevention

- Elevate the head of the bed to prevent edema formation

Post-operative Visual Loss: Strategies for Prevention

- Properly pad and protect the eyes from compression
Proper positioning of ProneView™ Pillow

**Post-operative Visual Loss: Strategies for Prevention**

- Occlusive dressing over eyes to prevent entry of surgical prep solutions
- Stage long procedures into two or more short procedures?

**BUT**

Is Staging Safer Than A Single Surgery?

- Nationwide Inpatient Sample
- 1998-2006
- 11265 circumferential spine surgeries
- Increased incidence (28.4% vs. 21.7%) of complications including:
  - DVT
  - ARDS
- Age > 65 years old also increased risk

**Post-operative Visual Loss: Strategies for Prevention - Updated**

- Avoid direct pressure on globe
- Avoid perioperative hypotension
- Avoid perioperative anemia
- Consider 10 degrees of reverse Trendelenburg during prone surgery
  - Lower transfusion threshold to keep hematocrit above 30-
  in high risk patients
- Avoid infusions of large amounts of crystalloid
- Consider staging long spinal surgeries (greater than 8-
  hours)
- Maintain mean arterial pressure at patient’s baseline
- Perform a postoperative visual exam as early as possible in high risk patients

Updated ASA Practice Advisory on POVL
*Anesthesiology* 2012; 116:274-85

- Use of deliberate hypotension not been shown to be associated with ION
- Colloids should be used along with crystalloids
- No documented hemoglobin level associated with development of ION
- Insufficient evidence to provide guidance on use of α-
  adrenergic agents
- High-risk patients should be positioned so head is level
  with or above heart and head in neutral forward position
- Consider staging procedures in high risk patients?

Controversial Strategies

- Avoid the use of N₂O:
  N₂O will ↑ plasma homocysteine by disrupting folate/B6/B12 metabolism; high homocysteine correlated with enhanced inflammation, diabetic neuropathy, and CRAO/CRVO
  Kempen PM *Anesthesiology* 2012; 117: 431-2
- Restrict crystalloid to 40 ml/kg total for spine case:
  Based on findings that total volume of resuscitation, total non-blood replacement, and lower use of colloid were risk factors
  Larson CP *Anesthesiology* 2012; 117: 433-4

CRASH 2013
Can we prevent post-operative vision loss?

*MAYBE,*

But there is still a lot we do not know!