Perioperative Visual Loss Associated with Spine Surgery

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Website/Resources:
www.asaclosedclaims.org
Miller’s Anesthesia Sixth Edition
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Introduction

- Rare, estimated at 0.0008% to 0.003%.
- May be under-reported due to litigation.
- Questionably on the rise.
- In 1999 ASA established Postoperative Visual Loss Database with 23 patients.
- Will focus on varying degrees of visual loss, including blindness, following spine surgery in the prone position.
Anatomy of the Visual Pathway

- **Cornea/Lens**—focus light on retina
- **Iris**—controls amount of light
- **Ciliary body**—produces aqueous humor

![Diagram of the eye](image)
- 3 chambers:
  - Anterior -- cornea to iris
  - Posterior -- iris to ciliary body to vitreous
  - Vitreous -- contains jelly-like vitreous humor

- Layers:
  - Sclera, Choroid, Retina
Retina

- **Outer retina contains photoreceptors, rods and cones.**
  - Rods: night vision and motion detection
  - Cones: central reading and color vision

- **Inner retina contains neurons for transmission of visual information to the brain**
FUNDUS of the Human Eye

1. OPTIC DISC (NERVE HEAD)
2. ARTERY
3. VENOUS CUP
4. MACULA

Examination of the fundus with a +90 diopter ophthalmoscope allows us to study the blood vessels, optic disc, and the surrounding tissues.

Blood vessels are observed for size, tortuosity, and the presence of overt and occult vascular abnormalities.

Study of the optic disc may reveal signs of retinal disease and other abnormalities.
Fovea Centralis (Macula)

- Retina thins
- No support structures, few nerve fibers, no rods
- Consists entirely of cones—suited for color and acute vision.

(Williams EL: Anesth Analg 1995;80:1018-29)
Ocular Blood Supply

- Ophthalmic artery--supplies most of eye
- Ocular branches--
  - Central Retina Artery (CRA)
  - Posterior Ciliary Artery Trunks (PCA)
- CRA sends branches to supply retina and optic nerve (ON).
- Main PCAs divide into short PCAs (sPCAs).
- sPCAs supply posterior choroid and portion of the ON.
Ocular Blood Supply

- Circle of Zinn-Haller
  - formed by the medial and lateral sPCAs around the ON.
  - from here are derived the pial and choroid branches.
  - subject to anatomic variation
  - complete in 77% of humans
- PCA supply is subject to individual variation.  
- PCAs are end-arteries without anastamosis.  
- Region between each end-artery supply is a watershed zone.  
- Hypotension could lead to poor perfusion.
Figure 82-5 The locations of the watershed zones between the medial and lateral posterior ciliary arteries are shown in gray.
Posterior Optic Nerve

- Blood supply - pial arteries and branches of CRA.
- Anatomic variation can influence watershed geography.
- Blood flow less than the anterior ON.

(Williams EL: Anesth Analg 1995;80:1018-29)
Choroidal Vessels

- Provide oxygen to outer layers of retina, where photoreceptors are located.
- 60-80% of retinal oxygen supply is from choroid.
- Blood flow is high (2000 ml/min/100g) and oxygen extraction is low (3%).
- Relatively large oversupply of perfusion.
Retinal Vessels

- Nourishes the inner 2/3 of the retina.
- Blood flow is low (40-100 ml/min/100g) and extraction is high (38%).
- Relatively limited blood flow to neuronal ganglia cells that have a low tolerance to ischemia.

(Williams EL: Anesth Analg 1995;80:1018-29)
Retina and Choroid

- Autoregulates with changes in arterial blood pressure, oxygen and CO2 tension.
- Inhalation of hypercapneic gas increases blood flow.
- Atherosclerosis is associated with defective autoregulation.
- Blood flow may be altered with anesthesia and surgery.
Visual Loss: Symptoms

- Blurry vision to complete blindness
- Unilateral or bilateral
- Complete or partial loss of light
- Unfamiliar to most anesthesia providers
- May be attributed to anesthetics, eye ointment.
- All patients with symptoms should receive an ophthalmologic exam.
Central Retinal Artery Occlusion

- Decreases blood flow to entire retina.

- Mechanisms of injury:
  - 1. Emboli -- incidence of microemboli after OHS is almost 100%.
  - 2. Atheromatous disease
  - 3. Inflammation, such as arteritis
  - 4. Vasospasm
  - 5. Increased IOP and/or local venous congestion resulting in low retinal perfusion pressure:
    - I.e. external pressure on the eyes in the prone position or the surgical ligation of the external jugular veins.
CRAO Resulting from Low Retinal Perfusion Pressure

- **RPP=MAP - IOP - CVP**
  - Increased risk with deliberate hypotension/prone
- **Improper positioning of head--compression of ocular and peri-orbital contents.**
- **Increased incidence:**
  - Altered facial anatomy
  - Osteogenesis Imperfecta
  - Exophthalmos
  - Asian descent with lower nasal bridge
  - In older reports, use of horseshoe headrest.
Eye Injury Issue Leads to New Protective Helmet Device and Research on Face Pressures from Prone Positioning on OR Table
Normal Fundoscopy

- Normal Optic Disk
- Normal Vessels without Hemorrhage
- Healthy Yellow-Red Retina
CRAO Fundoscopy

- Retinal pallor-ischemia
- Narrowed retinal arterioles
- Cherry-red spot in the fovea-retina is ischemic and underlying choroid is visible.
Central Retinal Artery Occlusion

- Neck/nasal surgery-highest proportion of CRAO due to direct vascular damage or spasm
- Other Symptoms:
  - Possible Ocular Muscle Impairment
  - Facial or Periorbital Edema
- Prognosis:
  - In most cases, permanent loss of vision
- Treatment:
  - No satisfactory treatment--ocular massage, IV Diamox, 5% CO2 inhalation, localized hypothermia
Central Retinal Artery Occlusion

- Prevention
  - Avoid compression of globe--surgeon’s arm
  - If prone, use of padded headrest with eye/nose opening
  - If head does not fit in foam headrest, consider securing head in pins.
  - Intermittent exam of eyes in prone position
  - Position head straight down in neutral position.
  - Limited usage of deliberate hypotension with prone Trendelenberg
  - “Air Maneuvers” and TEE during CP Bypass
Ischemic Optic Neuropathy (ION)

- Occurs after surgery or non-surgical bleeding
- Develops spontaneously
- Leading cause of sudden visual loss in patients >50 years old
- Can be either arteritic or non-arteritic
- Two types:
  1. Anterior Ischemic Optic Neuropathy (AION)
     - more common and more extensively studied
  2. Posterior Ischemic Optic Neuropathy (PION)
Ischemic Optic Neuropathy
(Williams EL: Anesth Analg 1995;80:1018-29)

- **AION**--
  - caused by interruption of blood supply to anterior portion of optic nerve.

- **PION**--
  - produced by decreased oxygen delivery to the posterior, retrolaminar portion of the optic nerve.
Arteritic Ischemic Optic Neuropathy

- **Anterior**
  - Inflammatory process due to temporal arteritis--biopsy to confirm.
  - Majority of patients have had flu-like symptoms.
  - Must emergently be treated with steroids.

- **Posterior**
  - Very rare inflammatory process
  - Found with systemic lupus, sickle cell disease.
Causes of Perioperative Anterior Ischemic Optic Neuropathy

- Anatomic and physiologic variations in the circulation of the optic nerve
  - Underperfused areas of the anterior optic nerve are found especially in patients with increased IOP and systemic hypotension.
- Small optic disk may play role in AION susceptibility
  - Axons that pass through narrowed opening into eye are prone to injury.
Surgeries in Which AION and PION Have Occurred:

- **Supine Position:**
  - Cardiac and Cardiovascular Surgery *
  - Abdominal, OB and Gyn Surgery
  - Head and Neck Surgery *

- **Lateral Position:**
  - Thoracotomy
  - Hip Surgery

- **Prone Position:**
  - Spine Surgery *
Fundoscopy of Acute Anterior Ischemic Optic Neuropathy

- Early stages: Optic disk swelling (edema) and a splinter hemorrhage at the optic disk margin
Acute Anterior ischemic optic neuropathy

Fluorescein fundus angiograms during the early stages of AION, showing no circulation in parts of the choroid and optic disc (dark areas correspond to absence of filling by fluorescein dye).
Posterior Ischemic Optic Neuropathy

- Area not as well-vascularized as the anterior portion of optic nerve (ON).
- Caused by low-flow state from systemic hypotension; emboli or venous stasis could contribute to PION.
- Initial period can be symptom-free.
- Initial normal fundoscopy.
- Within 6 weeks, optic disk atrophies and becomes pale.
Factors Associated with Perioperative Ischemic Optic Neuropathy

- Systemic hypotension
- Blood loss/anemia
- Increased intraocular pressure
- Abnormal autoregulation of ON circulation
- Anatomic variation of ON vasculature
- Emboli
- Use of vasopressors
- Presence of systemic disease
- Retrobulbar hemorrhage
Factors Related to Ischemic Optic Neuropathy

- **Hypotension**
  - Not present in all cases but cited as important.
  - Can lead to decrease in perfusion pressure of optic nerve (ON).
  - Anterior ON at risk because of anatomic variation or abnormal autoregulation.
  - Posterior ON at risk because of limited blood supply to area.
  - “Safe” lower limits of blood pressure not known.
Factors Related to Ischemic Optic Neuropathy

- **Blood Loss / Anemia**
  - From case reports, considerable blood loss.
  - Decreased hemoglobin levels intraoperatively.
  - Presently, routine clinical practice based on NIH Panel on Blood Transfusion is not to transfuse for Hgb $> 8$ g/dL.
  - Are decreased Hgb levels placing patients at risk for ION?
Factors Related to Ischemic Optic Neuropathy

- **Increased Intraocular Pressure**
  - ION reported with massive fluid replacement in prone position.
  - Many cases report no pressure to orbits (head in pin holders).

- **Massive fluid therapy with or without prone**
  - Increased IOP
  - Accumulation of fluid in the optic nerve (ON).
  - Small vessels on ON compressed, resulting in decreased arterial supply
  - Increased orbital venous pressure, venous stasis
Factors Related to Ischemic Optic Neuropathy

- Autoregulation and Anatomic Variation of the Optic Nerve
  - Anatomic variation may predispose to ION.
  - Location of potential watershed zones in ON circulation plus the presence of disturbed autoregulation in healthy patients cannot be predicted at this time.
  - 20% of healthy patients with increased IOP have been found to have abnormal autoregulation.
Factors Related to Ischemic Optic Neuropathy

- **Emboli**
  - Most likely to occur during cardiac surgery.
  - Air embolism through patent foramen ovale

- **Vasopressors**
  - Anterior ION related to excessive secretion of vasoconstrictors, lowering optic nerve perfusion.
  - Case reports of patients with ION after prolonged use of epinephrine and phenylephrine during operative procedure.
Factors Related to Ischemic Optic Neuropathy

- Patients with Hypertension, DM, CAD, or Previous Stroke
  - Not present in all patients
  - Typically found in patients for cardiac surgery.
  - Theory that perioperative ION is related to atherosclerosis -- ON vasculature responds abnormally to changes in perfusion pressure (disturbed autoregulation).
Factors Related to Ischemic Optic Neuropathy

- **Retrobulbar Hemorrhage**
  - Direct surgical injury to ON
  - Indirect damage by compression more common
  - Paresis of eye muscles often seen
  - Outcome poor, usually permanent blindness
MULTIFACTORIAL (MAJOR FACTORS) CAUSATION OF ION (BLINDNESS) FOLLOWING ORTHOPEDIC SURGERY IN THE PRONE POSITION

ABDOMINAL COMPRESSION

HEAD DOWN

VENOUS PRESSURE

THORACIC COMPRESSION

PRESSURE FROM HEADREST PRONE POSITION

ARterial Flow of Oxygen

ION/BLINDNESS

↓BP

↓Hb

↓SpO2
Ischemic Optic Neuropathy

- Prognosis and Treatment
  - No proven treatment
  - Diamox lowers IOP, may improve flow to anterior ON and retina.
  - Diuretics may decrease edema
  - Corticosteroids may decrease ON swelling in acute phase.
  - Increasing systemic BP / Hgb level
  - Maintain head-up position to decrease ocular venous pressure.
  - Surgical ON decompression ineffective
Ischemic Optic Neuropathy: Prevention

- Status of patient’s ON circulation is unknown.
  - Presently, no effective ON monitoring available.
- Maintain systemic blood pressure as close to baseline as possible (BP > 75% of control).
- If vasopressors are used to maintain BP, impact on ON vasculature not known.
- Consider Hgb optimization vs. lowest acceptable (Hgb > 9 g/dL, Hct > 27%).
- Maintain SaO2 > 95% (? low PEEP).
Ischemic Optic Neuropathy:

**Prevention**

- CVP placement to monitor venous pressure.
- Minimize protracted periods of prone and prone/Trendelenberg positions.
- Proper positioning.
- Avoid abdominal compression.
- Assure adequate chest excursion.
- Avoid external pressure to orbits.
- Discuss the risk of ION with surgeon.
Informed Consent?

- Controversial
- Despite potential devastating injury, only theories exist to the cause of ischemic optic neuropathy.
- Few clinicians include in informed consent.
- Consider including with:
  - Jehovah’s Witness patient
  - Case in which surgeon requests deliberate hypotension/hemodilution in prone position.
## Preliminary Data From ASA Postoperative Visual Loss Registry: Associated Factors From Spine Cases*

<table>
<thead>
<tr>
<th></th>
<th>Ischemic Optic Neuropathy (n=43)</th>
<th>Central Retinal Artery Occlusion (n=7)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age—years, median (range)</td>
<td>49 (19-73)</td>
<td>49 (35-71)</td>
</tr>
<tr>
<td>Headrest:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mayfield tongs</td>
<td>8 (18%)</td>
<td>0</td>
</tr>
<tr>
<td>Horseshoe</td>
<td>0</td>
<td>2 (29%)</td>
</tr>
<tr>
<td>Foam</td>
<td>33 (77%)</td>
<td>3 (43%)</td>
</tr>
<tr>
<td>Unknown</td>
<td>2 (5%)</td>
<td>2 (29%)</td>
</tr>
<tr>
<td>Prone time—hours, median (range)</td>
<td>8 (3-24)</td>
<td>5.5 (3.4-9)</td>
</tr>
<tr>
<td>EBL(^1) liters, median (range)</td>
<td>2.3 (0.2-20.0)</td>
<td>0.7 (0.5-1.3)</td>
</tr>
<tr>
<td>Lowest Hct percentage, median (range)</td>
<td>25.5 (19-40)</td>
<td>33 (29-38)</td>
</tr>
<tr>
<td>Bilateral disease</td>
<td>25 (58%)</td>
<td>0</td>
</tr>
<tr>
<td>No vision recovery</td>
<td>24 (56%)</td>
<td>7 (100%)</td>
</tr>
</tbody>
</table>

*Three cases with unknown diagnosis for vision loss not shown. \(^1\)EBL = estimated blood loss
Practice Advisory:
Anesthesiology 2006; 104: 1319-28
Summary

- ION - multifactorial causes
  - Predisposing factors remain unknown.
  - “Safe” limits for hypotension and hemoglobin levels have not been validated.
  - Have documentation of surgeon’s demand for deliberate hypotensive prone procedures.

- CRAO - avoid compression of globe.

- All patients experiencing visual changes need an ophthalmology consult.

- Statistics regarding your patient experiencing postoperative visual loss.