The Case:

- A 64 yo man with chronic back pain has elective multilevel lumbar spinal surgery

The Case:

- Upon awakening from anesthesia, he is blind in both eyes

Perioperative Visual Loss After Non-Ocular Surgeries

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Financial Disclosures

- Consultant for GenSight Biologics
- Data Safety Monitoring Board Quark Study
- Medical-legal consultant

Learning Objectives

At the end of this talk, participants will:

- Recognize the many different locations within the visual system where vision loss can occur after nonocular surgeries
- Understand that the mechanisms for visual loss in these settings depends on the location of the injury and the type of surgical procedure
- Be aware of the complexity of factors that contribute to ischemic optic neuropathy in the perioperative setting

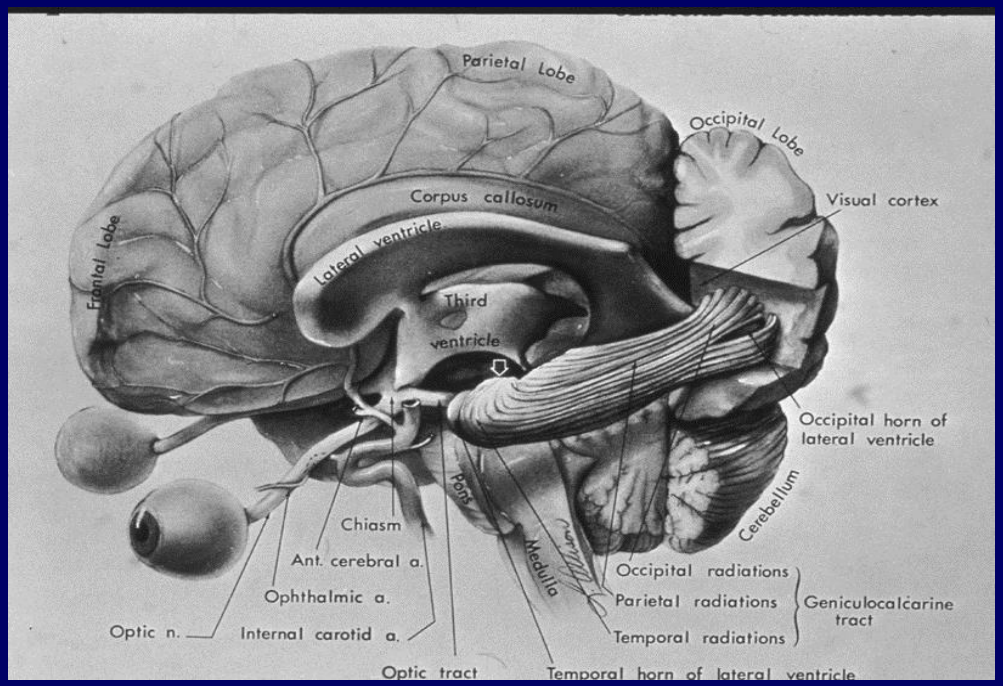
Perioperative Visual Loss

- General anesthesia
- Non-ocular/non-cranial procedures
- Persistent visual loss

- Prevalence (1996-2005 NIS survey):
  - 1326/5,679,422 (0.023%)

Perioperative Visual Loss Location

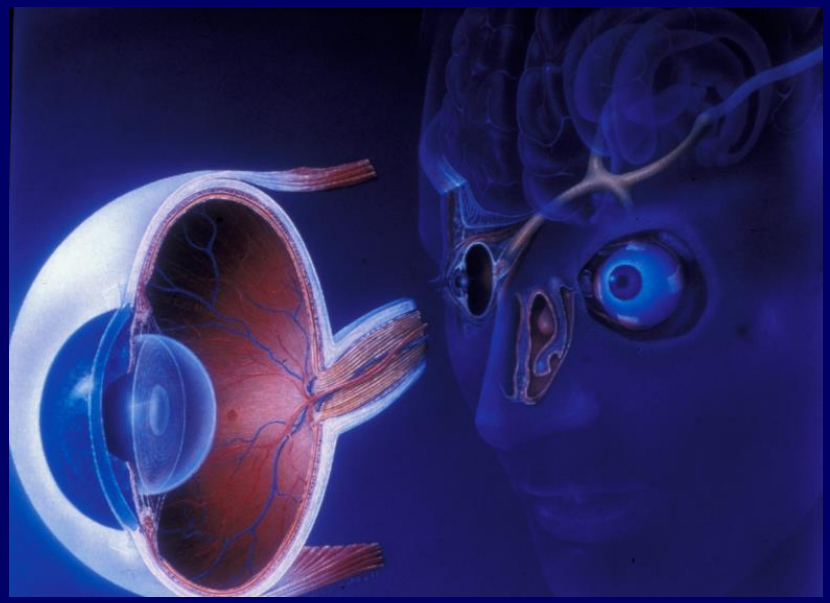
- Ocular
- Retinal
- Optic Nerve
  - Anterior
  - Posterior
- Chiasm
- Retrochiasmal Pathways



Perioperative Visual Loss Mechanism

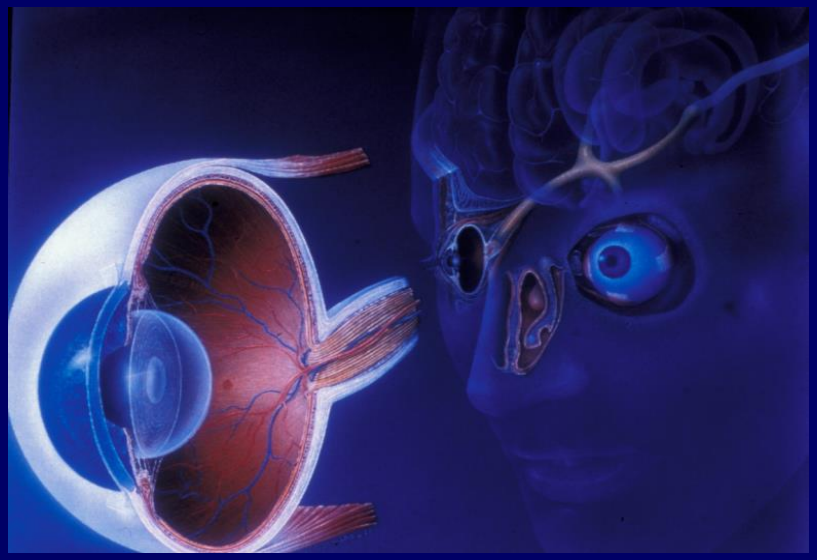
- Depends on location

- Ocular compression
- Tumor compression
- Vascular compromise
- Anoxia



Perioperative Visual Loss Where?

- The ophthalmologist can see the problem: it's the eye!
- The ophthalmologist can't see the problem: it's the brain!



Perioperative Visual Loss
Ocular

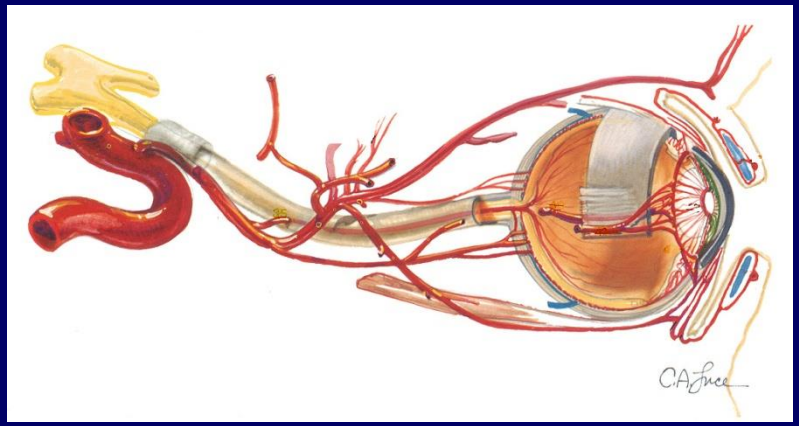
- Usually unilateral

- Conjunctival heme
- Corneal abrasion
- Corneal edema
- EOM problem

- Mechanism: compression

Perioperative Visual Loss
Retina/Choroid

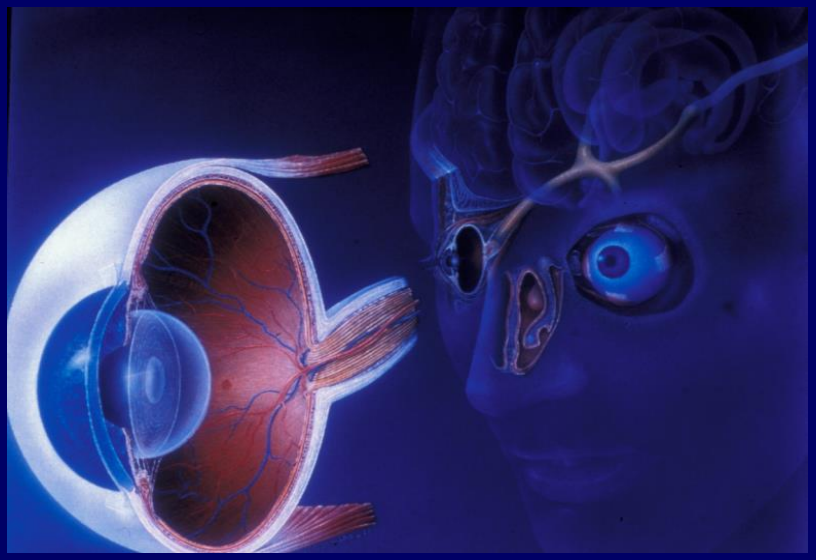
- Usually unilateral
- CRAO
- Abnormal FA



- Mechanisms
  - Embolism
  - Compression – sustained ↑ intraocular pressure

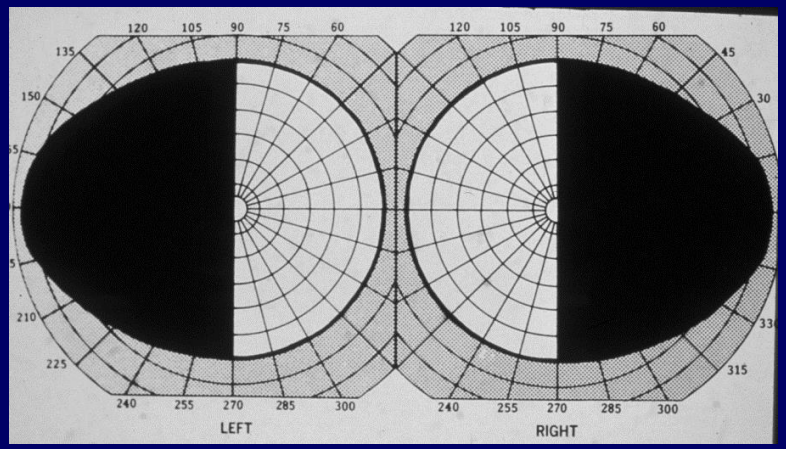
Perioperative Visual Loss Where?

- The ophthalmologist can see the problem: it's the eye!
- The ophthalmologist can't see the problem: it's the brain!



Perioperative Visual Loss
Chiasm

- Bitemporal hemianopia or binocular blindness
- Pituitary tumor
- Mechanism: apoplexy

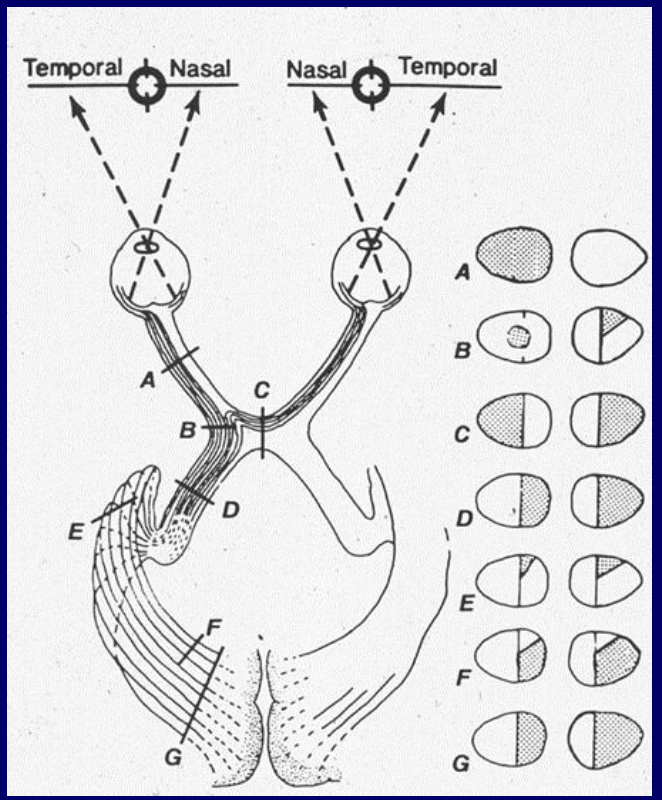


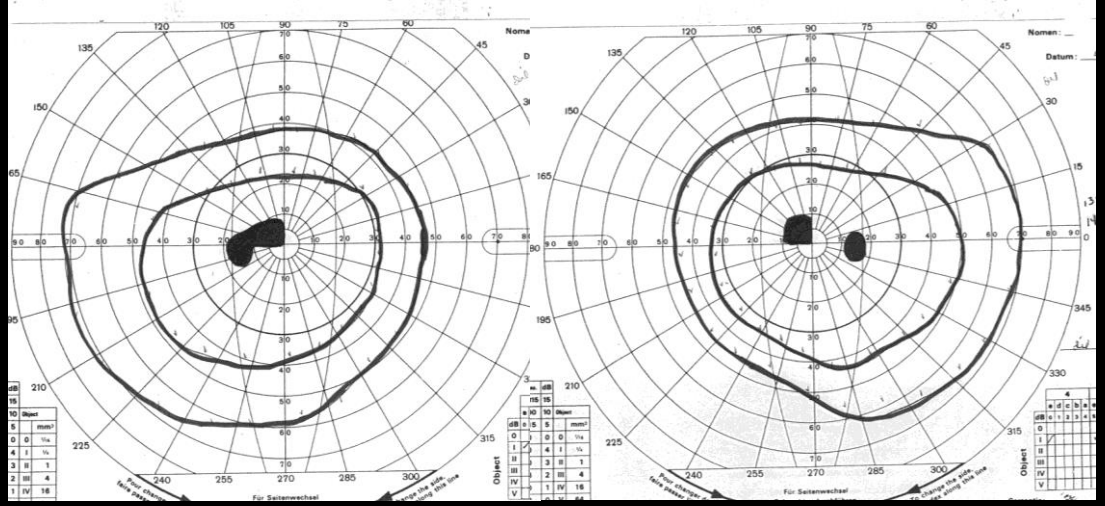
Perioperative Visual Loss
Retrochiasmal Pathways

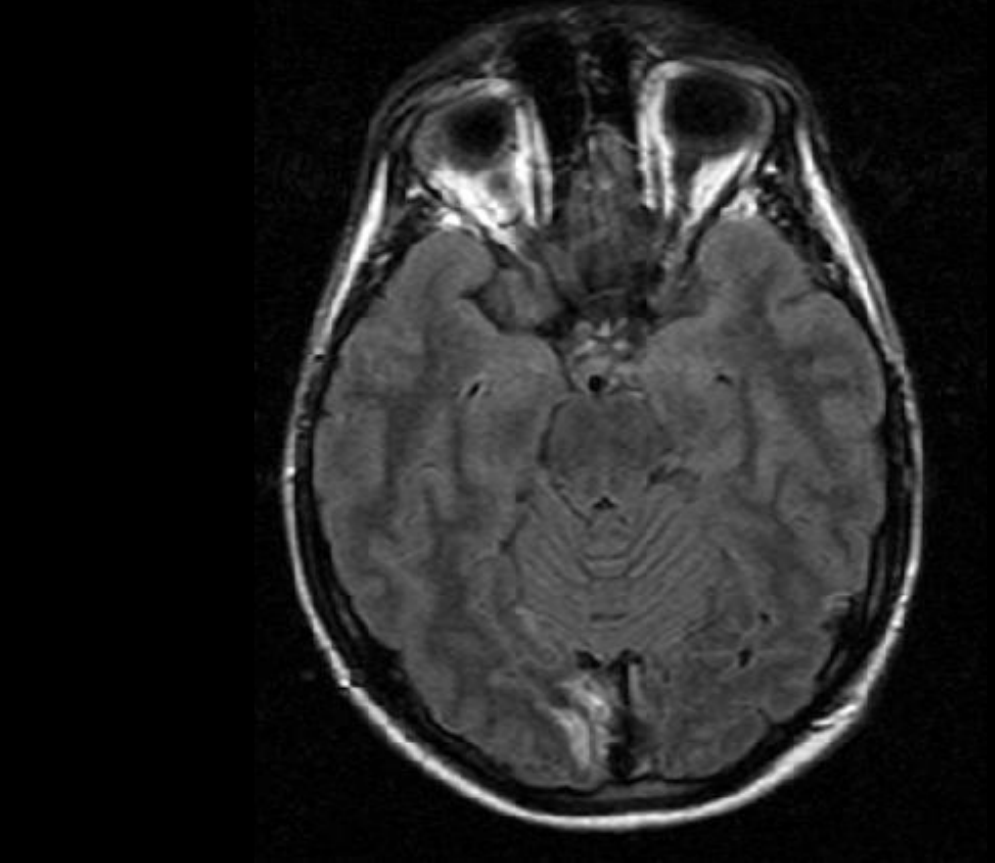
- Homonymous hemianopia
- Cerebral blindness

- Normal pupils, fundi

- Mechanisms:
  - Infarction:
    - embolism, watershed
  - Anoxia





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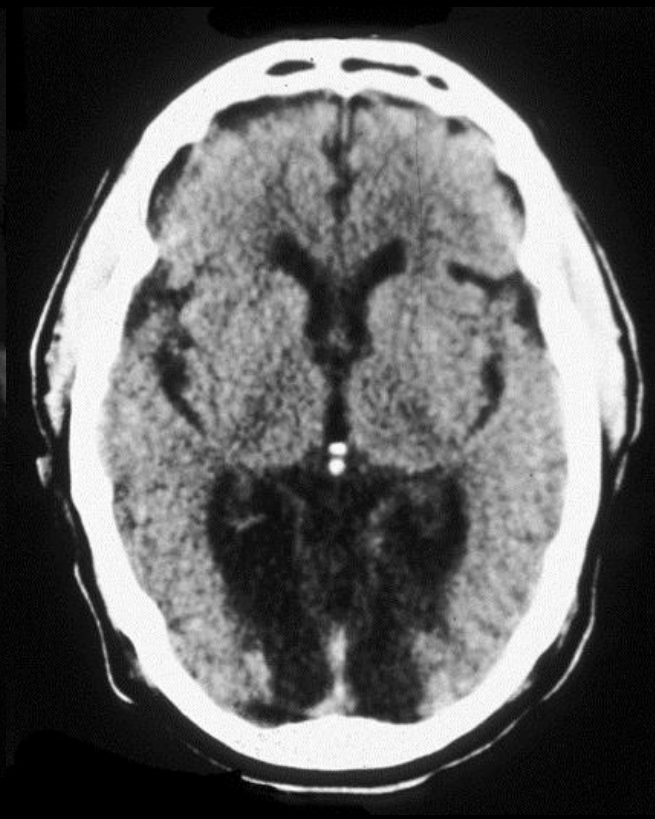

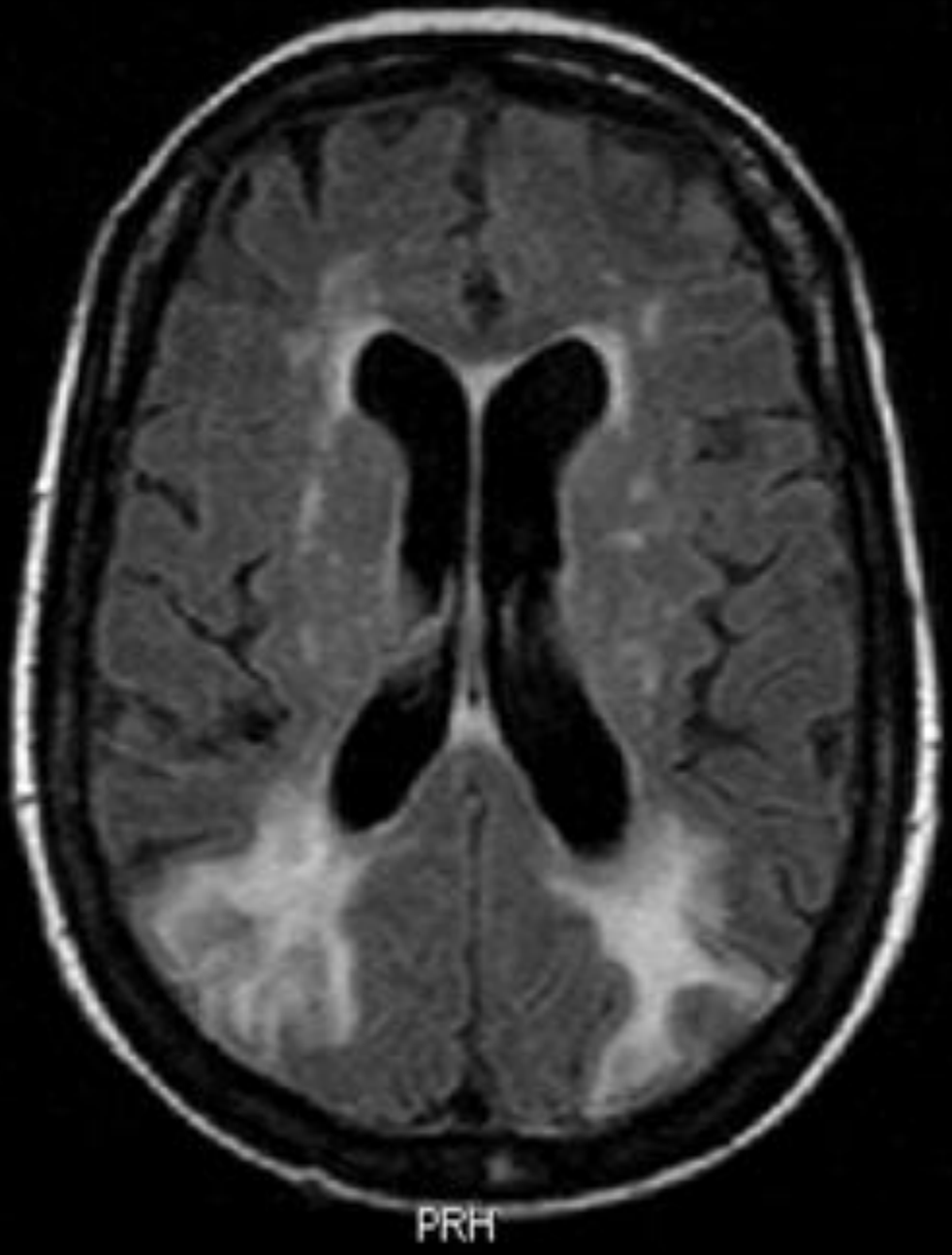
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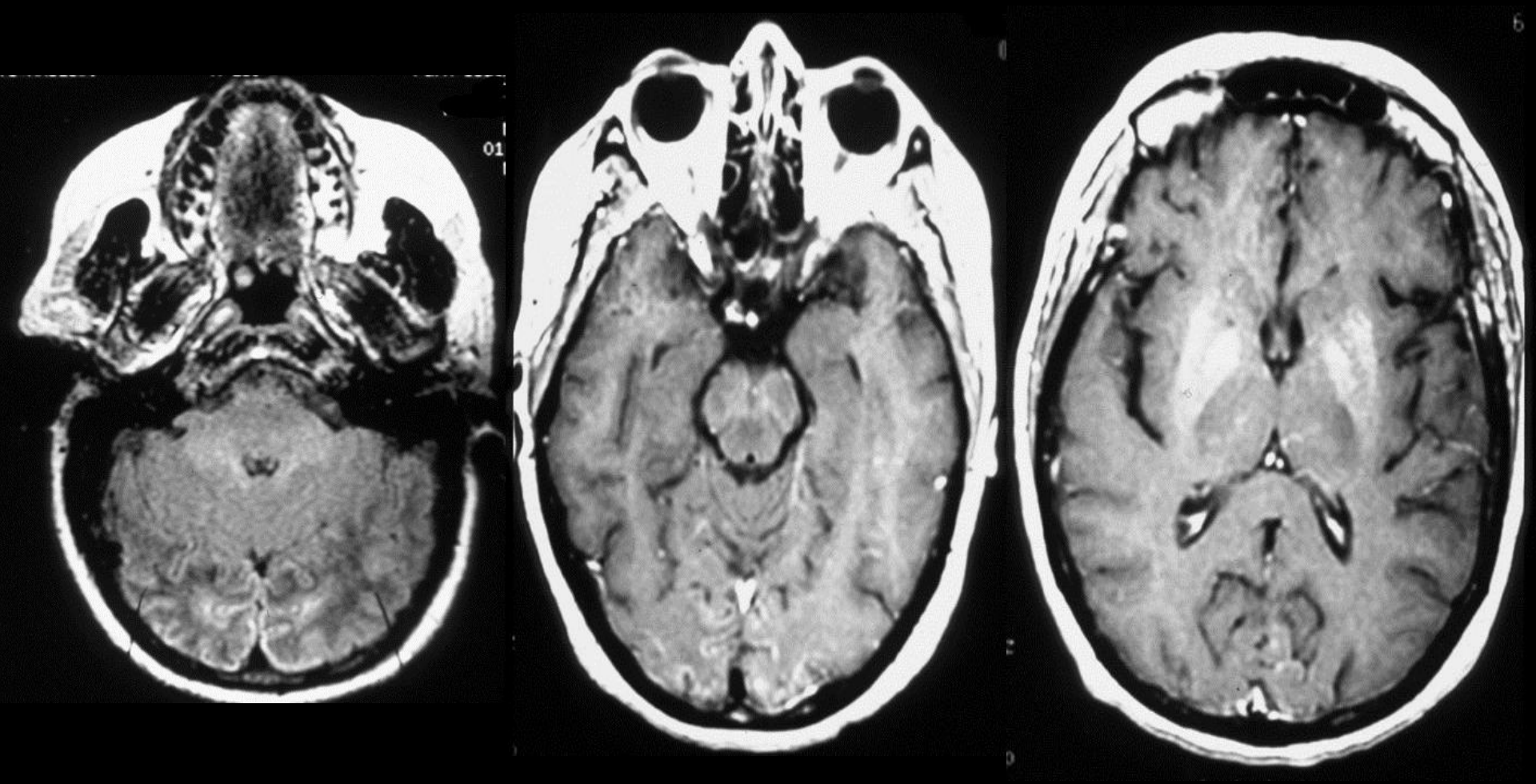
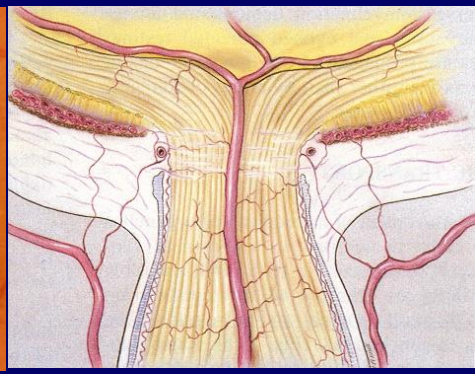
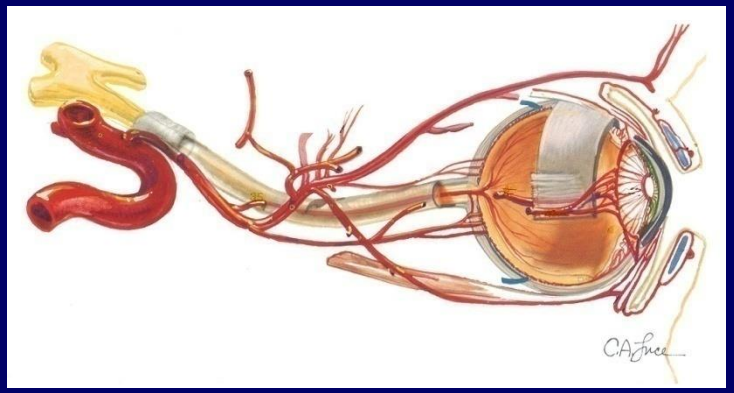


Perioperative Visual Loss
Optic Nerve

- Anterior optic nerve
  - Acute: swelling of disc
  - > 6 wks: pallor of disc



- Posterior optic nerve
  - Acute: normal fundus
  - > 6 wks: pallor of disc



- Mechanism: ischemia

Perioperative Visual Loss
Ischemic Optic Neuropathy

- Common cause of peri-op visual loss

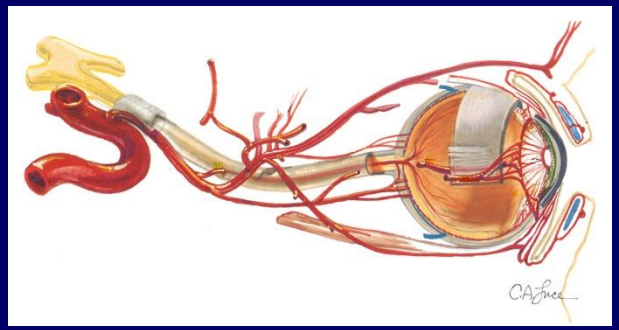
- CABG – (0.06%-0.33%) – AION
- Spine – (0.006%-0.36%) – PION

- Often bilateral blindness
- Medical-legal issues

Perioperative Visual Loss
Ischemic Optic Neuropathy

- Age range 5-81 years (mean about 50)
  - Spine pts younger than CABG pts
- Male predominance
- Vision loss upon awaking from surgery
  - Rarely delayed (usually CABG)
- Bilateral in at least 66%
- Severe permanent vision loss
  - < CFs in 75%
  - NLP in 46-54%

Perioperative Visual Loss
ION – Proposed Factors



- Patient factors:
  - Male sex
  - Obesity
  - Vascular risk factors – HTN, DM, cigs
  - Thrombotic risk factors
  - Anatomic variation
    - Cup-to-disc – AION
    - Vascular anatomy – PION

Perioperative Visual Loss
ION – Proposed Factors

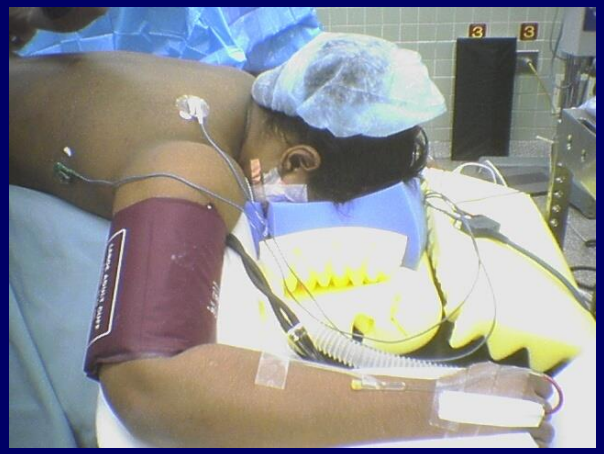
- Surgery factors:
  - CABG
  - Spine surgery:
    - complex fusion and instrumentation
    - Prone position
    - Long procedure -- ≥ 6 hrs
    - Wilson frame

Perioperative Visual Loss
ION – Proposed Factors

- **Intraoperative factors:**
  - Hypotension or relative hypotension
  - Blood loss
  - Anemia
  - Hypoxia

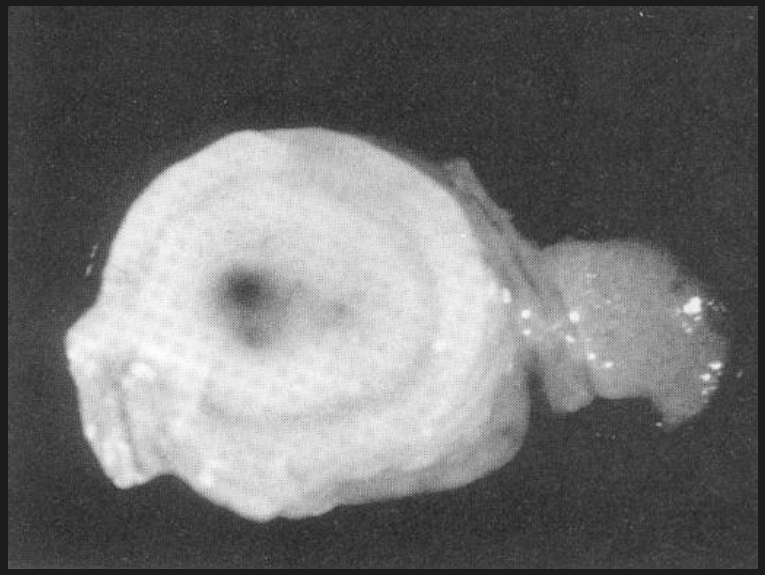
Perioperative Visual Loss
ION – Proposed Factors

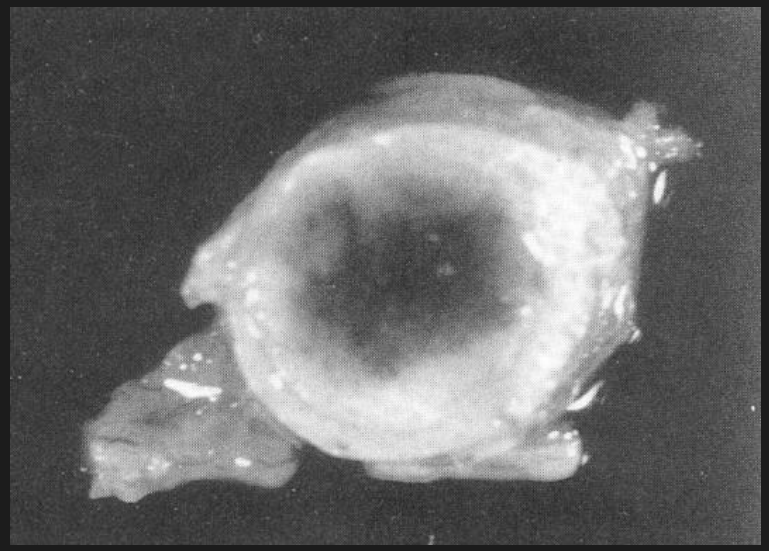
- **Intraoperative factors:**
  - Hemodilution
  - Large crystalloid administration
  - Hypovolemia
  - Use of vasopressors
  - Venous congestion
  - Head position
  - ~~Ocular compression~~

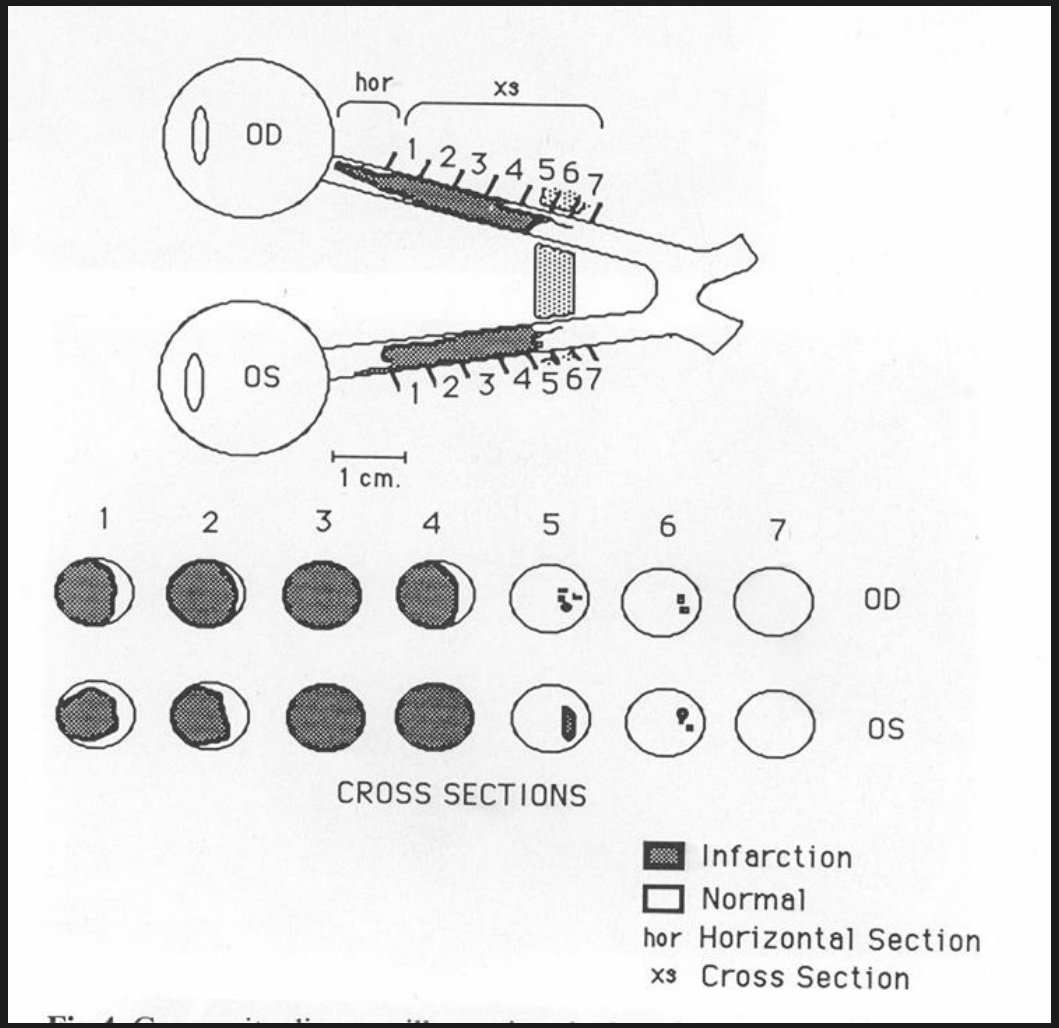


Perioperative Visual Loss
ION – Proposed Factors

- Are these factors simply features of these types of surgery?
- Are they causal or just associated?
- Are they markers of another mechanism?
- Do the causal factors differ among different procedures and even among different pts?







Johnson MW, Kincaid MC, Trobe JD. Ophthalmology 1987;94:1577-1584

Perioperative Visual Loss
ION – Pathology

- Bilateral radical neck dissection PION cases:
  - Hemorrhagic infarction of the central portion of the intraorbital optic nerve -- *Marks S et al. Head and Neck 1990;12:342-5; Nawa Y et al. Graefe's Arch Clin Exp Ophthalmol 1992;230:301-8*
  - Relative sparing of central optic nerve axons with loss of concentric peripheral fibers -- *Schobel GA et al. Int J Oral Maxillofac Surg 1995;24:283-7*

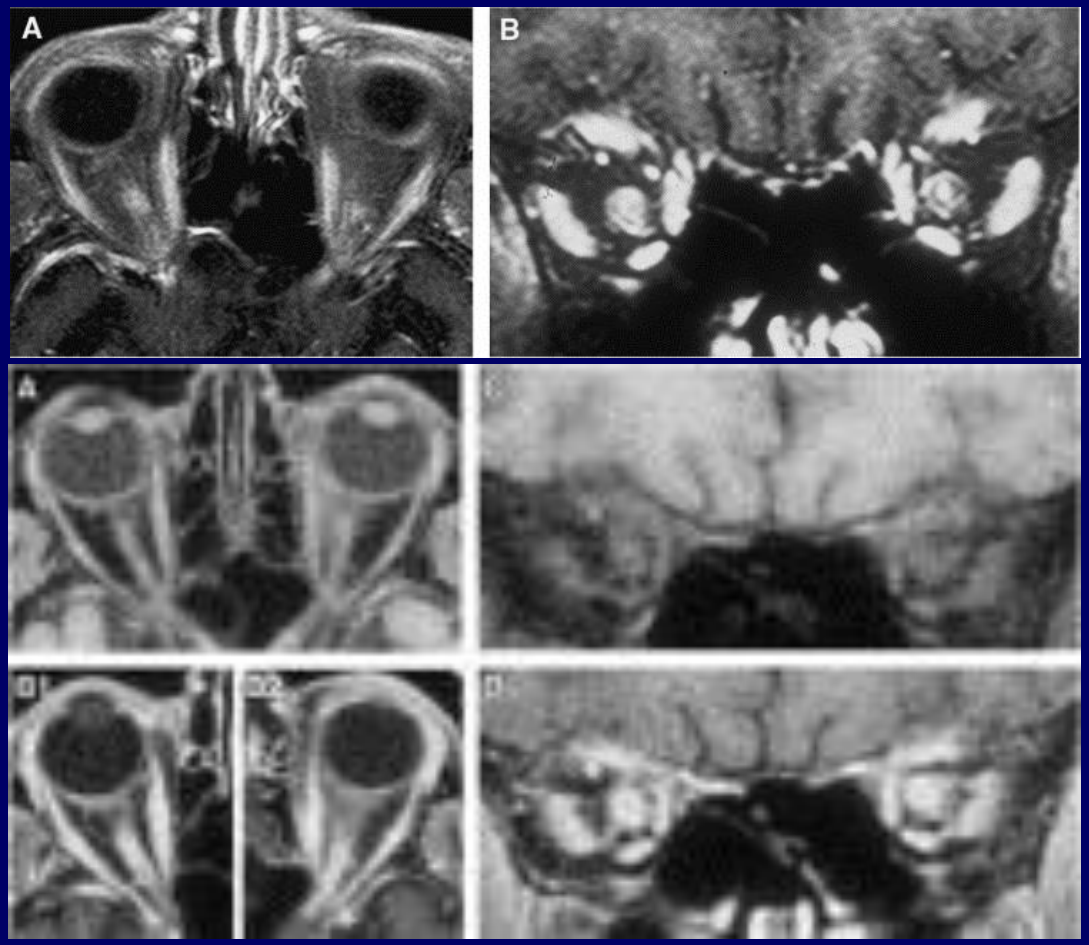
Perioperative Visual Loss
PION – Imaging

57 W with PION s/p CABG

Vaphiades M. JNO 2004

8 wks post-op

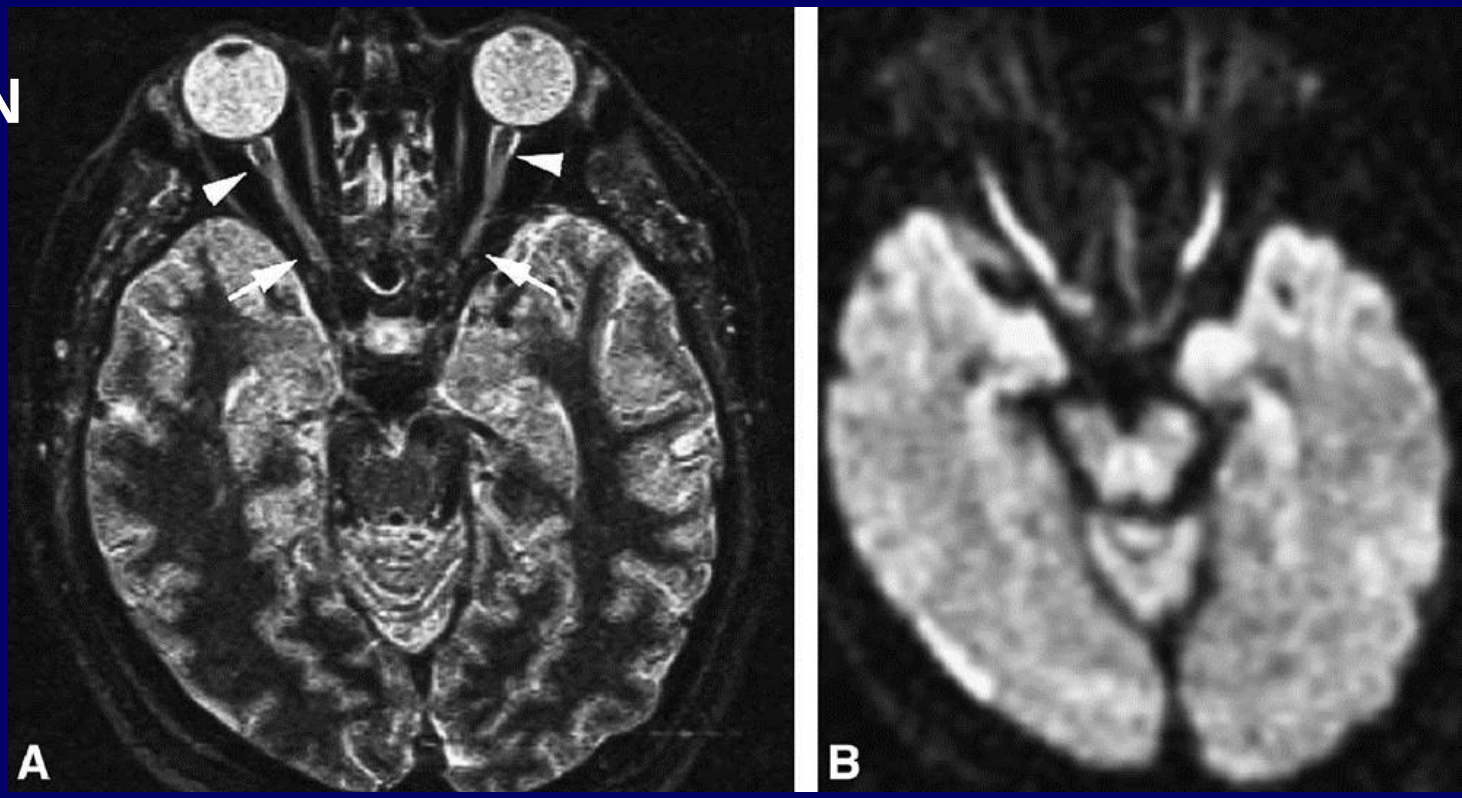
16 wks post-op



Perioperative Visual Loss
PION – Imaging

61 M with PION s/p CABG

4 days post-op



Purvin and Kuzma. JNO 2005

Perioperative Visual Loss
ION – Porcine Model

(Lee LA, Deem S, Glenny RW et al. Anesthesiology 2008;108:775-6)

- Pigs subjected to:
  - Euvolemic or hypovolemic hypotension; anemia; venous congestion
- Results:
  - No change with eu-hypotension
  - + compensation cerebrally for hypo-hypotension and anemia, but not for optic nerve oxygen delivery
- Pig optic nerve more susceptible than pig brain; multiple factors likely necessary

Perioperative Visual Loss
ION – Rat Model

(Roth S, Dreixler J, Newman NJ. Eur J Anesthesiol 2018;e-pub)

- Rats subjected to:
  - Head down (venous congestion), hemodilution, or both for 5 hrs
- Results:
  - Head down + hemodilution caused the most injury similar to human ION
  - Hemodilution alone also caused functional changes
- Provides animal model to study mechanisms and potential interventions

Perioperative Visual Loss
ION – Proposed Factors

- Case-control study (1997):
  - Only spine procedures
  - ION cases predominated
  - No difference in Hct or BP
  - Longer procedures
  - Greater blood loss

Myers MA, et al. Visual loss as a complication of spine surgery: a review of 37 cases. Spine 1997;22:1325-1329

Perioperative Visual Loss
ION – Proposed Factors

- Case-control study (2009):
  - 17 ION cases from 126,666 surgeries
  - 9/17 after CABG; 4/17 after spine
  - No difference in any hemodynamic parameter between cases and controls matched for procedure type

Holy SE, et al. Perioperative ischemic optic neuropathy. A case control analysis of 126,666 surgical procedures at a single institution. Anesthesiology 2009;110:246-53.

Perioperative Visual Loss
ASA Registry

- **American Society of Anesthesiologists Postoperative Visual Loss Registry:**
  - Established in 1999
  - Prospective collection of reported cases
  - Anonymous
  - Standardized detailed forms
  - By June 2005 – 131 cases

Anesthesiology 2006; 105:652–9

The American Society of Anesthesiologists Postoperative Visual Loss Registry

Analysis of 93 Spine Surgery Cases with Postoperative Visual Loss

Lorri A. Lee, M.D., Steven Roth, M.D.,† Karen L. Posner, Ph.D.,‡ Frederick W. Cheney, M.D.,§ Robert A. Caplan, M.D.,‖ Nancy J. Newman, M.D.,# Karen B. Domino, M.D., M.P.H.***

CME This article and its accompanying editorial have been selected for the *Anesthesiology* CME Program. After reading both articles, go to http://www.asahq.org/journal-cme to take the test and apply for Category 1 credit. Complete instructions may be found in the CME section at the back of this issue.

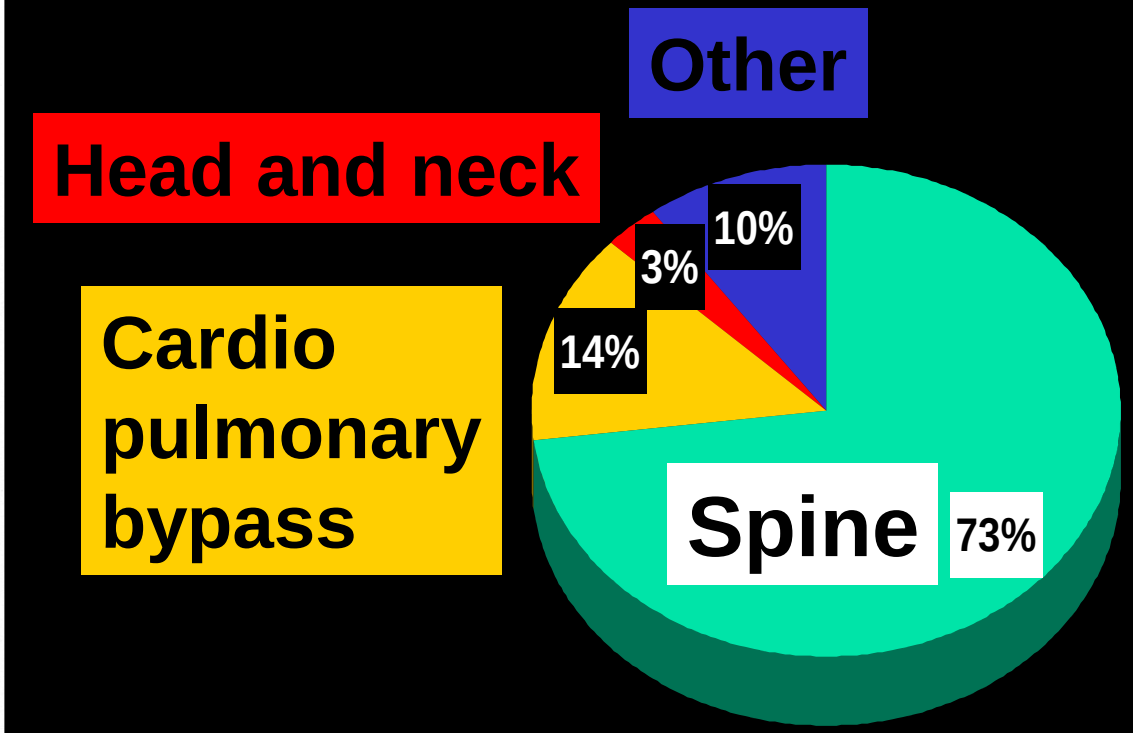
Background: **Postoperative visual loss after prone spine surgery is increasingly reported in association with ischemic optic neuropathy, but its etiology is unknown.**

Methods: **To describe the clinical characteristics of these patients, the authors analyzed a retrospectively collected series of 93 spine surgery cases voluntarily submitted to the American Society of Anesthesiologists Postoperative Visual Loss Registry on standardized data forms.**

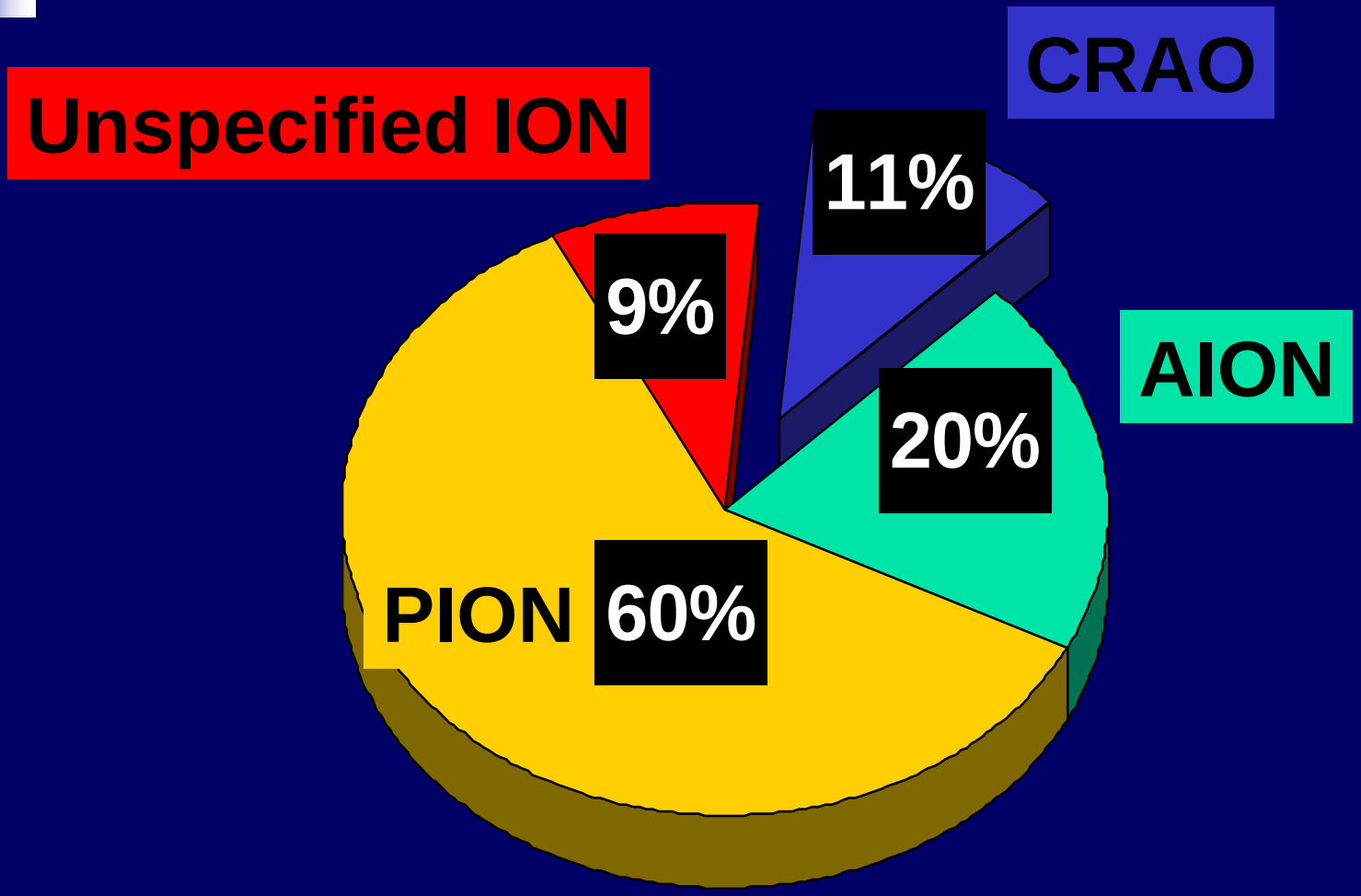
Results: **Ischemic optic neuropathy was associated with 83 of 93 spine surgery cases. The mean age of the patients was 50 ± 14 yr, and most patients were relatively healthy. Mayfield pins supported the head in 16 of 83 cases. The mean anesthetic duration was 9.8 ± 3.1 h, and the median estimated blood loss was 2.0 l (range, 0.1–25 l). Bilateral disease was present in 55 patients, with complete visual loss in the affected eye(s) in 47. Ischemic optic neuropathy cases had significantly higher anesthetic duration, blood loss, percentage of patients in Mayfield pins, and percentage of patients with bilateral disease compared with the remaining 10 cases of visual loss diagnosed with central retinal artery occlusion ($P < 0.05$), suggesting they are of different etiology.**

Conclusions: **Ischemic optic neuropathy was the most common cause of visual loss after spine surgery in the Registry, and most patients were relatively healthy. Blood loss of 1,000 ml or greater or anesthetic duration of 6 h or longer was present in 96% of these cases. For patients undergoing lengthy spine surgery in the prone position, the risk of visual loss should be considered in the preoperative discussion with patients.**

ASA Registry- n=131



Perioperative Visual Loss
ASA Registry – Spine (n=93)



ASA POVL Registry: Spine Cases with ION

	n=83
Elective surgery	80 (96%)
Males	60 (72%)
Age mean (range)	50 (16-73)
Unilateral ION	28 (34%)
Bilateral ION	55 (66%)

ASA POVL Registry: Spine Cases with ION

- 94% of cases were ≥ 6 hours
- 82% of cases had EBL of ≥ 1 liter
- 96% of cases had either ≥ 6 hrs or ≥ 1 liter

- 17% of cases had a nadir Hct of ≥ 30%
- 33% of cases had nadir SBPs of ≥ 90 mmHg
- 20% of cases had nadir SBPs of ≤ 80 mmHg

ASA POVL Registry: Spine Cases

	Ischemic Optic Neuropathy (N = 83)	Central Retinal Artery Occlusion (N = 10)
Age (mean, SD)	50 (+/- 14)	47 (+/- 13)
Anesth time (mean, SD)	9.8 (+/- 3.1)	6.5 (+/- 2.2)*
EBL (median,range)	2.0 (0.1 - 25)	0.75 (0.5 - 1.8)*
Crystalloid (mean, SD)	9.7 (+/- 4.7)	4.6 (+/- 1.7)*
Lowest Hct (mean, SD)	26 (+/- 5)	31 (+/- 6)
Bilateral Disease (n)	55 (66%)	0 (0%)*
Mayfield Pins (n)	16 (19%)	0 (0%)*
Periocular Trauma (n)	1 (1.0%)	7 (70%)*

*$p < 0.05$

Anesthesiology 2006; 104:1319–28

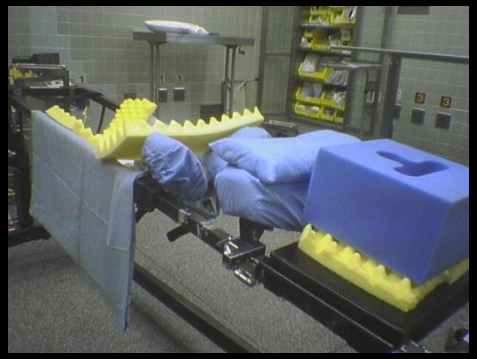
Practice Advisory for Perioperative Visual Loss Associated with Spine Surgery

A Report by the American Society of Anesthesiologists Task Force on Perioperative Blindness

PRACTICE advisories are systematically developed reports that are intended to assist decision making in areas of patient care. Advisories provide a synthesis and analysis of expert opinion, clinical feasibility data, open forum commentary, and consensus surveys. Advisories are not intended as standards, guidelines, or absolute requirements. They may be adopted, modified, or rejected according to clinical needs and constraints.

The use of practice advisories cannot guarantee any specific outcome. Practice advisories summarize the state of the literature and report opinions derived from a synthesis of task force members, expert consultants, open forums, and public commentary. Practice advisories are not supported by scientific literature to the same degree as standards or guidelines because of the lack of sufficient numbers of adequately controlled studies. Practice advisories are subject to periodic revision as warranted by the evolution of medical knowledge, technology, and practice.

with a spine procedure during which general anesthesia is administered. The perioperative period includes the time period from the immediate preoperative assessment through discharge from the acute healthcare facility. The conditions addressed in this advisory are posterior ischemic optic neuropathy [ION], anterior ION, and central retinal artery occlusion (CRAO). "High-risk patients" are defined as those who undergo spine procedures while positioned prone and who have prolonged procedures, experience substantial blood loss, or both.



Perioperative Visual Loss Practice Advisory

- Literature lacks adequately controlled studies
- Etiology of POVL incompletely understood
- Likely multifactorial
- Probably don't yet know all the factors
- "High-risk patient"
  - Prolonged prone spine surgery

  +/- substantial blood loss

Perioperative Visual Loss
"High-Risk Patient"

Consider:

- Add visual loss to the pre-op consent
- Position head at level of or higher than heart
- Use colloids in addition to crystalloids
- ? Avoid deliberate hypotension
- ? Transfuse at a higher hemoglobin
- ? Limit prolonged use of vasopressors
- ? Stage the procedure

Perioperative Visual Loss Nationwide Inpatient Sample Data

- ION in spine surgery decreasing (1998 to 2012)
  - Aging, male sex, obesity associated
- ION in cardiac surgery same incidence
  - Carotid stenosis, stroke, DM/HTN retinopathy, glaucoma, macular degen, cataracts associated

Rubin DS et al. Anesthesiology 2016;125:457-64

Rubin DS et al. Anesthesiology 2017;126:810-21

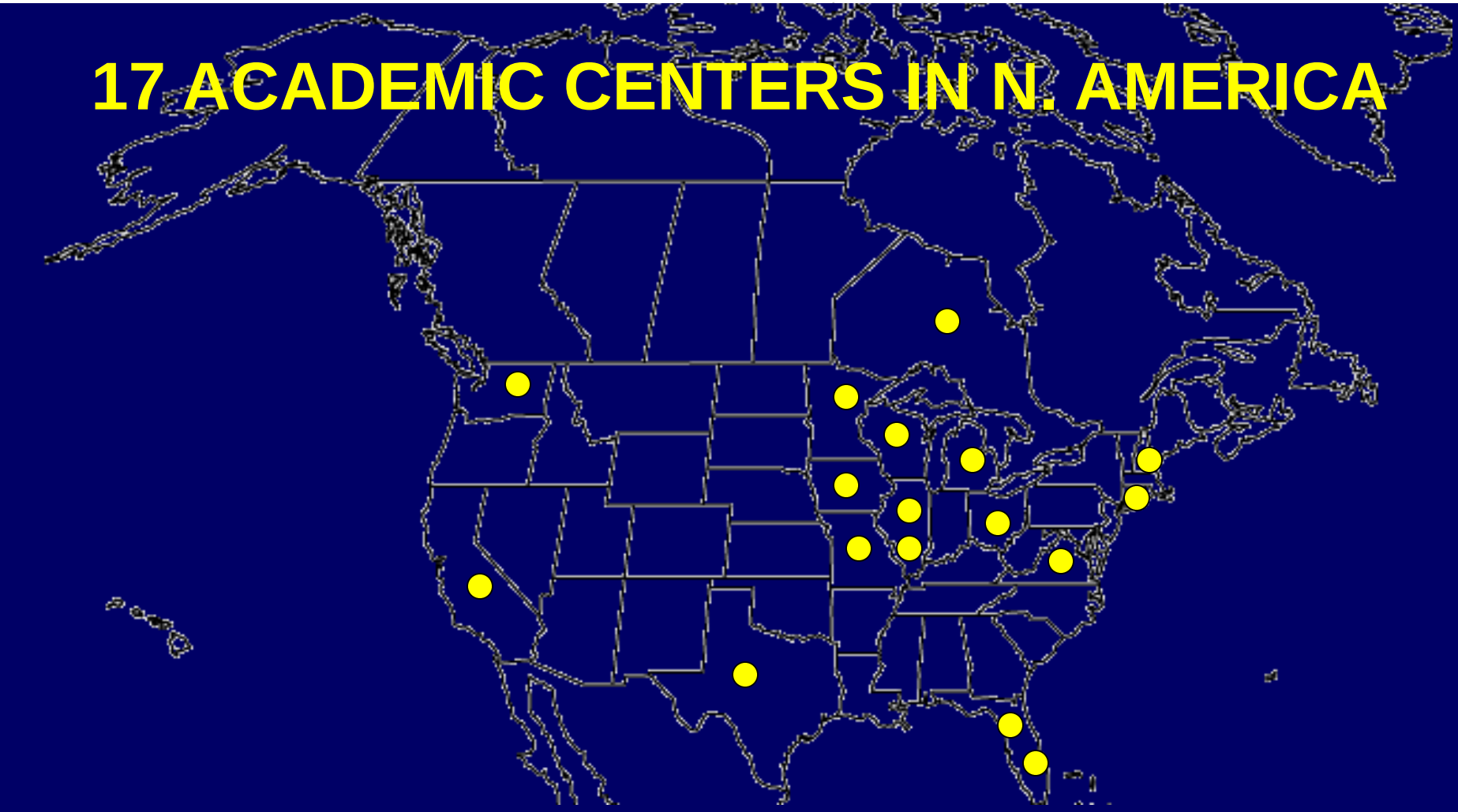
Perioperative Visual Loss Nationwide Inpatient Sample Data

- Retinal artery occlusion in spine surgery
  - DM retinopathy, carotid stenosis, aging, HLD, stroke, emergent surgery associated
- Retinal artery occlusion in cardiac surgery
  - GCA, carotid stenosis, stroke, hypercoaguable, DM with ophthalmic abnls, open surgery, blood loss associated

Calway T et al. Ophthalmology 2017;124:189-196

Calway T et al. J Neuro-Ophthalmol 2018;38:36-41

Risk Factors Associated with Ischemic Optic Neuropathy after Spinal Fusion Surgery



Anesthesiology 2012; 116: 15-24

Risk Factors Associated with Ischemic Optic Neuropathy after Spinal Fusion Surgery

The Postoperative Visual Loss Study Group*

ABSTRACT

Background: Perioperative visual loss, a rare but dreaded complication of spinal fusion surgery, is most commonly caused by ischemic optic neuropathy (ION). The authors sought to determine risk factors for ION in this setting.

Methods: Using a multicenter case-control design, the authors compared 80 adult patients with ION from the American Society of Anesthesiologists Postoperative Visual Loss Registry with 315 adult control subjects without ION after spinal fusion surgery, randomly selected from 17 institutions, and matched by year of surgery. Preexisting medical conditions and perioperative factors were compared between

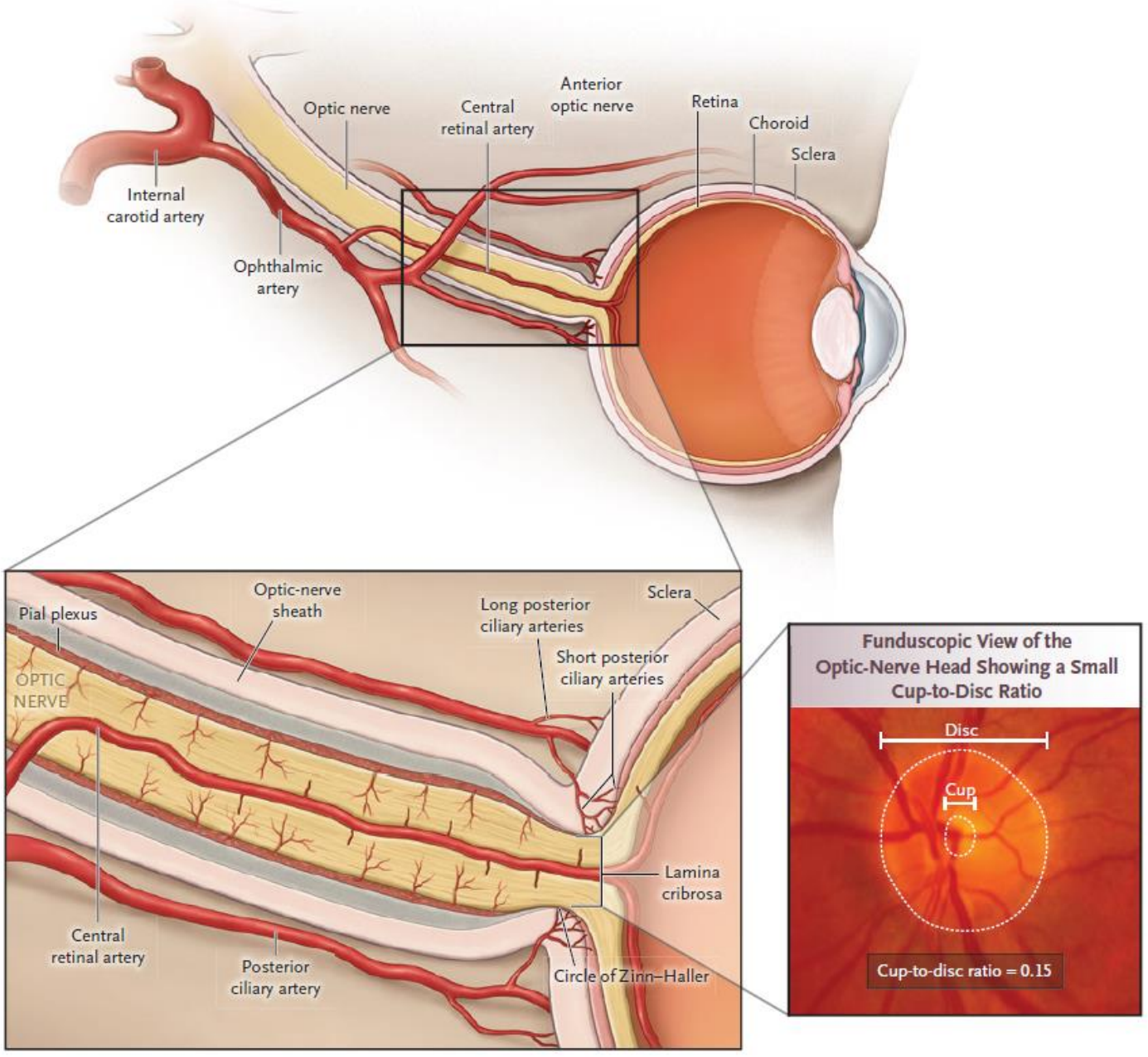
What We Already Know about This Topic

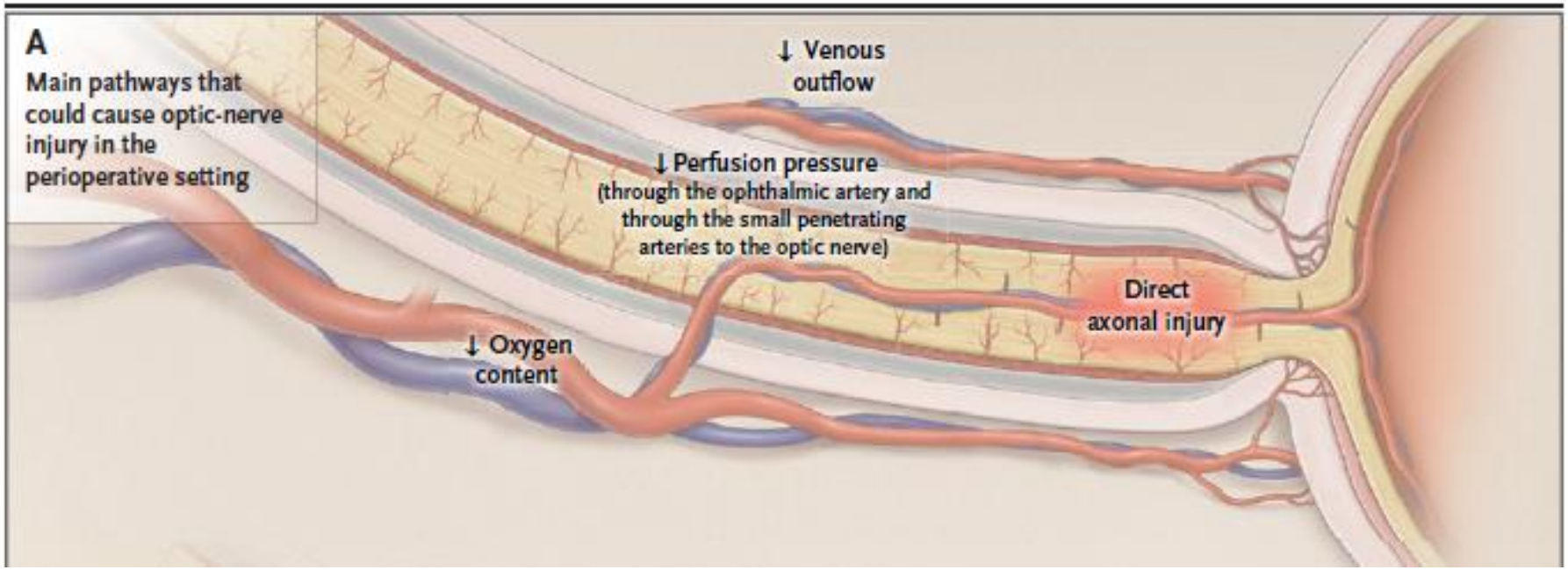
- Visual loss after spinal fusion surgery is a devastating complication most commonly caused by ischemic optic neuropathy (ION)
- The risk factors for ION after spinal fusion surgery have not been systematically evaluated with detailed perioperative data

What This Article Tells Us That Is New

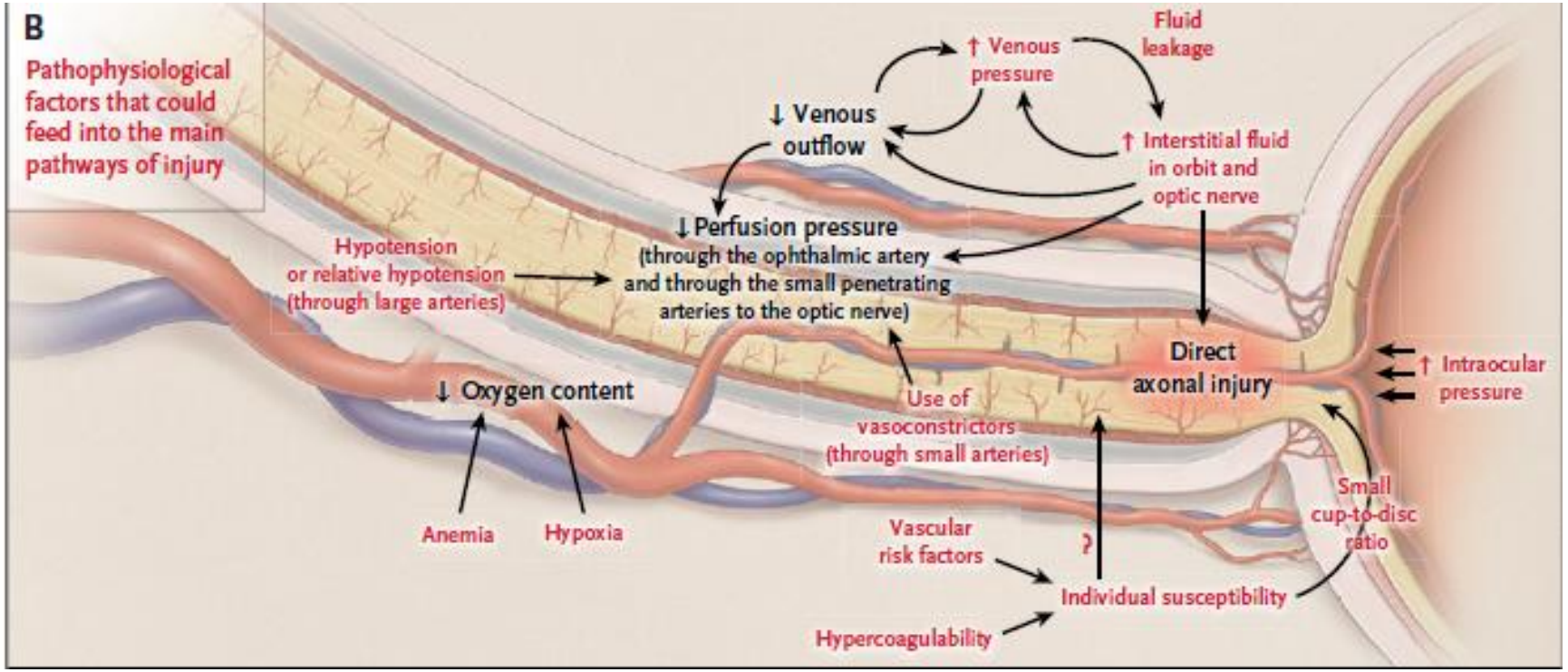
- In a case-control examination of 80 patients with ION compared with 315 matched control subjects, independent risk factors were male sex, obesity, Wilson frame use, longer anesthetic duration, greater estimated blood loss, and lower percent colloid administration

Anesthesiology 2012; 116: 15-24


Optic nerve
Central retinal artery
Anterior optic nerve
Retina
Choroid
Sclera
Internal carotid artery
Ophthalmic artery
Optic-nerve sheath
Pial plexus
Long posterior ciliary arteries
Sclera
Short posterior ciliary arteries
OPTIC NERVE
Lamina cribrosa
Central retinal artery
Posterior ciliary artery
Circle of Zinn–Haller
Funduscopic View of the Optic-Nerve Head Showing a Small Cup-to-Disc Ratio
Disc
Cup
Cup-to-disc ratio = 0.15



Biousse V, Newman NJ. Ischemic optic neuropathies.
N Engl J Med 2015; 372: 2428-36. See video at NEJM.org



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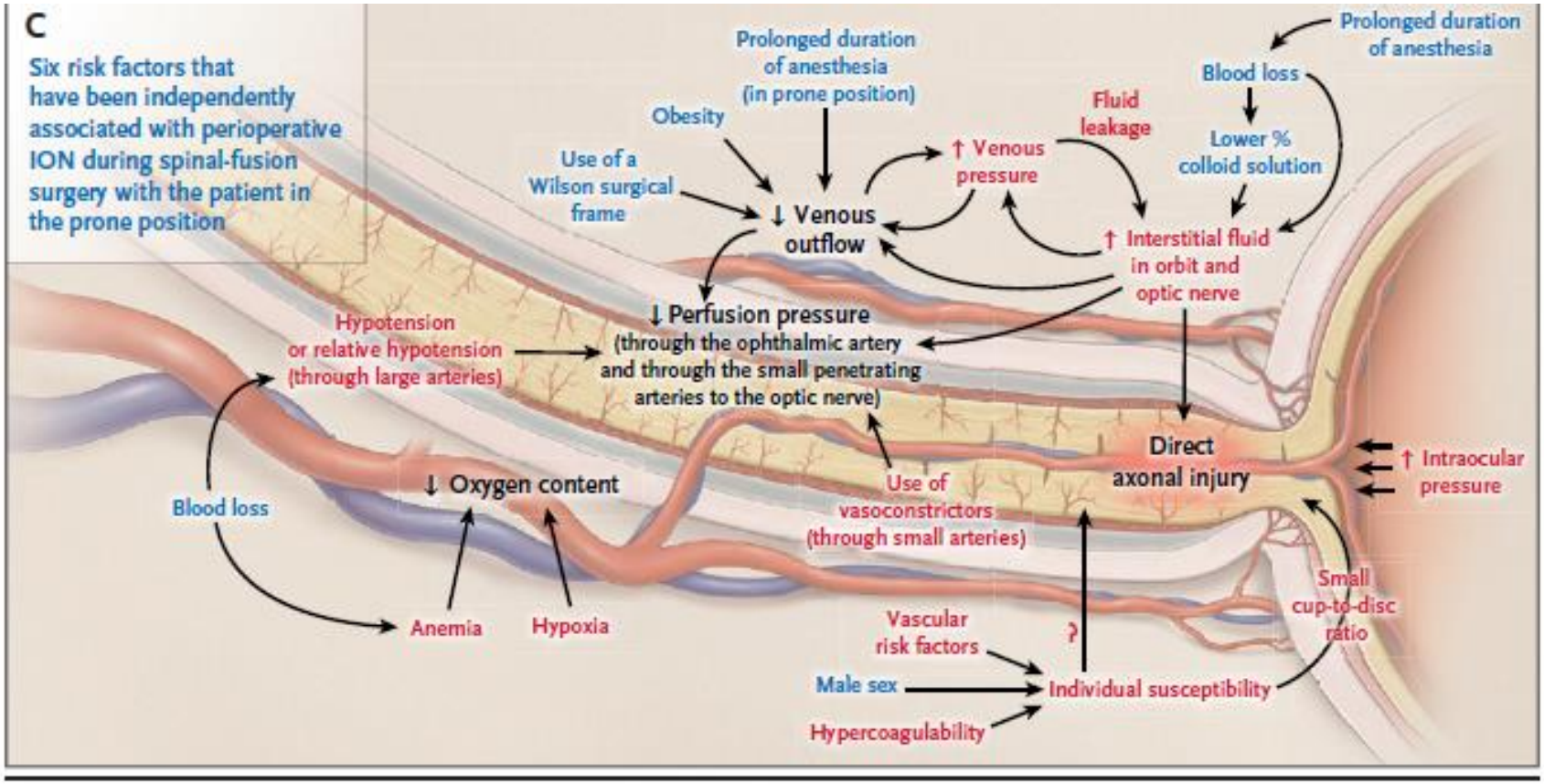
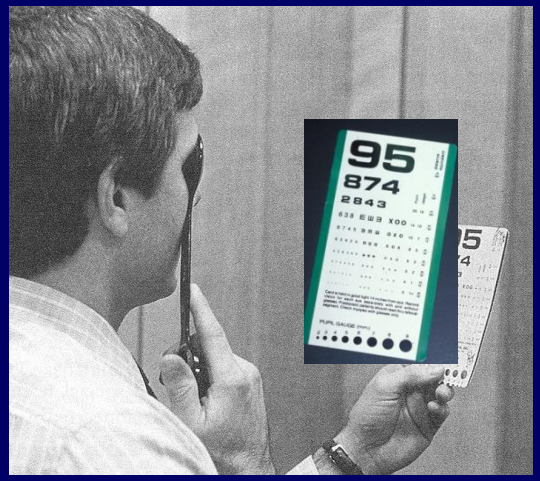


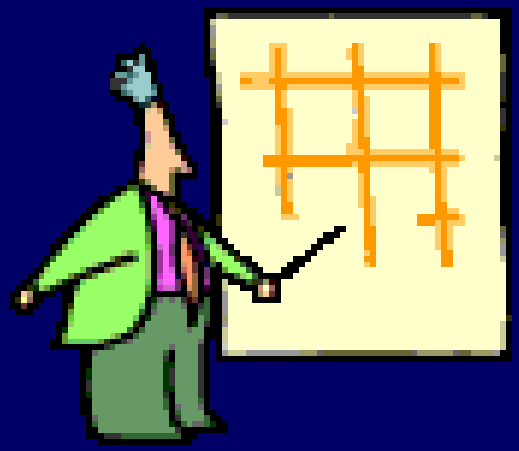
Biousse V, Newman NJ. Ischemic optic neuropathies.
N Engl J Med 2015; 372: 2428-36. See video at NEJM.org

Perioperative Visual Loss "High-Risk Patient"

- Assess patient's vision when becomes alert
- Brain MRI if visual loss and normal fundus



- There is no known effective Rx for ION



- DOCUMENT ACCURATELY IN THE CHART !!