POST-OPERATIVE VISUAL LOSS

A Preventable Complication?

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DISCLOSURE

I have no commercial or other conflicts of interest

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

Moos DD, Lind DM. Journal of Perianesthesia Nursing 2006; 21(5): 332-341
Gild WM, Posner KL, et al. Anesthesiology 1992; 76:204-8

- 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

Gild WM, Posner KL, et al. Anesthesiology 1992; 76:204-8
Lee LA, Posner KL, et al. Reg Anesth Pain Med 2008; 33:416-422

- 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

- 60,965anesthetics 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

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

Warner ME, Anesthesia & Analgesia 2001; 93: 1417-21

- Possible factors:
  - Anemia
  - Hypotension
  - Surgical Duration
  - Combination

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

Patil CG, Lad EM, et al. Spine 2008; 33(13): 1491-6

- 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 sxs
  - 271 (0.006%) had diagnosis of ION
  - 47 (0.001%) had diagnosis of CRAO
  - Overall incidence was 0.094%

Post-operative Visual Loss

Patil CG, Lad EM, et al. Spine 2008; 33(13): 1491-6

- 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

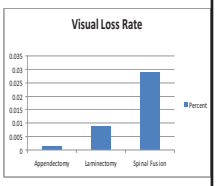
Patil CG, Lad EM, et al. Spine 2008; 33(13): 1491-6

- Risk factors for ION:
  - Hypotension: OR 10.1
  - Peripheral vascular disease: OR 6.3
  - Anemia: OR 5.9
- Note – this study did not define hypotension or anemia

Post-operative Visual Loss

Shen Y and Roth S, Anesthesiology 2008; 109: A1013

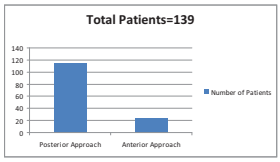
- Retrospective study using National Inpatient Sample from 1996 to 2005
- Rates of visual loss:
  - Spinal fusion – 1:3364 (0.029%)
  - Laminectomy – 1:11,453 (0.0087%)
  - Appendectomy – 1:78705 (0.0012%)
- Spinal fusion with visual loss:
  - 57% lumbar/lumbosacral
  - 35% thoracic/thoracolumbar
  - 8% cervical



Post-operative Visual Loss

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



Post-operative Visual Loss

Holy SE et al, Anesthesiology 2009; 110:246-53

- 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
Summary of Studies Reporting Incidence

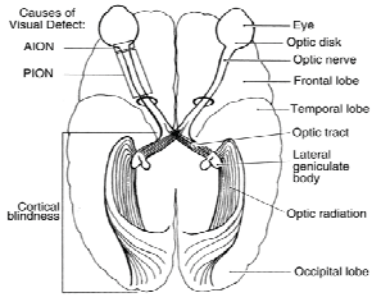
	Year	Population	Incidence
Roth, Thistead, et al	1996	General Surgical	0.003%
Warner, Warner, et al	2001	General Surgical	0.001%
Nuttall, Garrity, et al	2001	Cardiac	0.060%
Kalyani,Miller, et al	2004	Cardiac	0.113%
Stevens, Kelley, et al	1997	Spine	0.200%
Chang, Miller	2005	Spine	0.028%
Patil, Lad, et al	2008	Spine	0.094%
Shen, et al	2009	Spine	0.01%

Most Common Causes

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

Anatomic Classification of Visual Loss

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



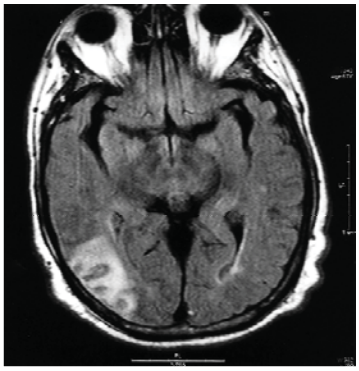
AION: Anterior ischemic optic neuropathy
PION: Posterior ischemic optic neuropathy

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

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 O_2 if air embolism is suspected



Non-hemorrhagic infarct in left occipital lobe

From Stambough JL, Dolan D, et al, J Am Acad Orthop Surg 2007; 15:156-165

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

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% CO_2?
- 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

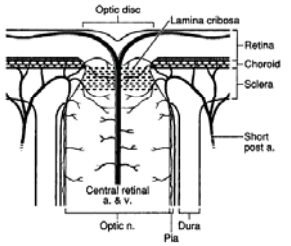


Figure 2. Diagram of the anterior optic nerve showing the arterial and small vessel supply to the choroid and optic nerve as it passes through the lamina cribrosa. Short post a = short posterior ciliary artery; a = artery; v = vein; n = nerve.

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

Anterior Ischemic Optic Neuropathy – Etiology

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

- Predisposing factors
  - Variable blood supply (posterior ciliary arteries)
  - Small optic disk size
  - Aging
  - Hypertension
  - Smoking
  - Diabetes mellitus
  - Vascular disease
- Precipitating Factors
  - Acute systemic hypotension*
  - Venous obstruction*
  - Raised intraocular pressure
  - Lowered hematocrit*
  - Increased blood viscosity (sickle cell; polycythemia)

Ischemic Optic Neuropathy – Visual Field Deficit

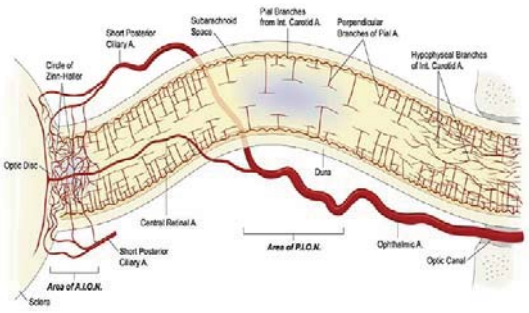
American Society of Anesthesiologists, Postoperative Visual Loss Registry

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

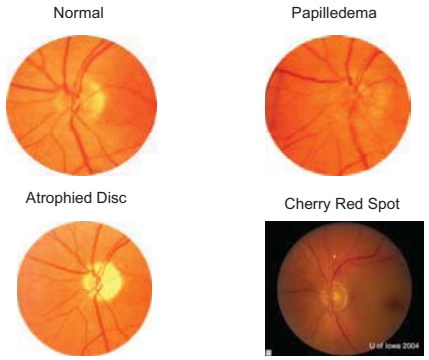
- Multifactorial:
  - Hypotension*
  - Low Hemoglobin*
  - Increased intraorbital venous pressure
  - Infection
  - Venous obstruction*
  - Congenital absence of central retinal artery
  - Internal carotid artery dissection

Posterior Ischemic Optic Neuropathy – Risk Factors

Dunker S, Hsu HY, et al. J Am Coll Surg 2002; 194:705-710

- 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



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 O_2 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

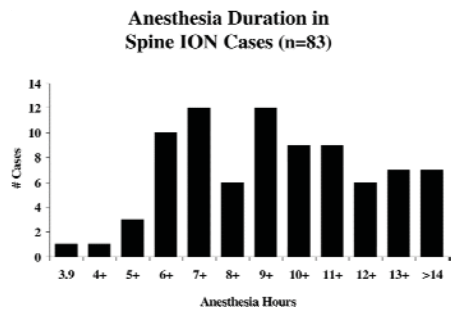
Post-operative Visual Loss

Lee LA, Anesthesia Patient Safety Foundation Newsletter 2003; 18(2): 17-32

- 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)

Post-operative Visual Loss

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



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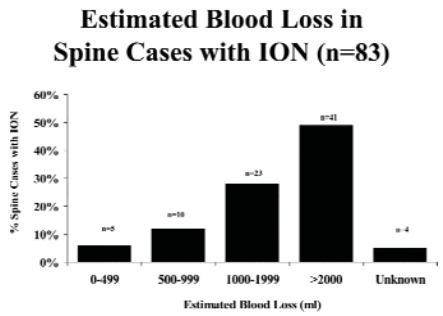


Post-operative Visual Loss

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

Table 6. ASA POVL Registry: Lowest Blood Pressure* in Spine Cases with ION (n = 83)

	n (% of 83 cases)
Lowest SBP, mm Hg	
=< 110	4 (5)
101–110	7 (8)
91–100	17 (20)
81–90	35 (42)
71–80	12 (14)
<= 70	5 (6)
Unknown	3 (4)
Lowest MAP or SBP as % below baseline, mm Hg	
=< 20%	5 (6)
20–39%	47 (57)
40–49%	21 (25)
=> 50%	7 (8)
Unknown	3 (4)
Deliberate hypotension	22 (27)

* Blood pressure ranges were based on 15 min of blood pressure at a given range.

ASA = American Society of Anesthesiologists; ION = ischemic optic neuropathy; MAP = mean arterial pressure; POVL = Postoperative Visual Loss; SBP = systolic blood pressure.

- Occurs over a wide range of reported blood pressures

Post-operative Visual Loss

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

Table 4. ASA POVL Registry: Type of Surgical Frames, Tables, and Headrests in Spine Cases with ION (n = 83)

	n (% of 83 cases)
Type of surgical frame or table	
Wilson frame	25 (30)
Jackson spinal table	22 (27)
Soft chest rolls	17 (20)
Knee–chest tables	7 (8)
Other/unknown tables	12 (14)
Type of headrest	
Foam pad	47 (57)
Mayfield pins	16 (19)
Donut/gel pad	7 (8)
Other/unknown	13 (16)

ASA = American Society of Anesthesiologists; ION = ischemic optic neuropathy; POVL = Postoperative Visual Loss.

- Any type of table; any type of headrest

Post-operative Visual Loss

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

Table 2. ASA POVL Registry Spine Cases with ION: Patient Characteristics (n = 83)

Demographics	n (% of 83 cases)
Age, mean (SD), yr	50 ± 14
Male	60 (72)
ASA I or II	53 (64)
ASA III	24 (29)
ASA IV	2 (2)
Emergency	3 (4)
Coexisting diseases	
Hypertension	34 (41)
Diabetes	13 (16)
Tobacco use	38 (46)
Coronary artery disease	8 (10)
Cerebrovascular disease	3 (4)
Increased cholesterol/lipids	11 (13)
Obesity	44 (53)
≥ 1 Coexisting diseases	68 (82)

American Society of Anesthesiologists (ASA) physical status data do not add up to 100% because of missing data in four cases.
ION = ischemic optic neuropathy; POVL = Postoperative Visual Loss.

- Most patients had one or more co-existing disease, but can happen in ASA Class 1 patients also

Post-operative Visual Loss

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

Table 5. Comparison of ION and CRAO Cases from the ASA POVL Registry (n = 93)

	ION (n = 83)	CRAO (n = 10)	P Value
Age, mean (SD), yr	50 (14)	46 (13)	0.34*
Anesthetic duration, mean (SD), h	9.8 (3.1)	6.5 (2.2)	0.002*
Estimated blood loss, median (range), l	2.0 (0.1-25)	0.75 (0.5-1.8)	0.001†
Crystalloid infusion, mean (SD), l	9.7 (4.7)	4.6 (1.7)	0.001*
Lowest hematocrit, mean (SD)	26 (5)	31 (6)	0.075*
Bilateral disease, number of cases (% of column)	55 (66)	0 (0)	0.001‡
Any visual recovery, number of cases (% of column)	35 (42)	2 (20)	0.11‡
Mayfield pins, number of cases (% of column)	16 (19)	0 (0)	0.001‡
Ipsilateral periocular trauma, number of cases (% of column)	1 (1)	7 (70)	0.001‡

* t test. † Mann–Whitney U test. ‡ Z test.
ASA = American Society of Anesthesiologists; CRAO = central retinal artery occlusion; ION = ischemic optic neuropathy; POVL = Postoperative Visual Loss.

Post-operative Visual Loss

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

- 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

Post-operative Visual Loss
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

BUT

Holy SE et al, Anesthesiology 2009; 110:246-53

PRE-OP	*INTRA-OP*	*POST-OP*
Sex/BMI	Procedure	Facial edema
MAP	Duration/Position	Lowest MAP
Hgb/Hct	Lowest MAP	Lowest Hgb/Hct
HTN/Stroke	Lowest Hgb/Hct	Use of blood products
Smoking	EBL/Use of Products	
DM/Renal Dz	Vasopressor use	
MI/↑ Cholesterol	CPB duration	

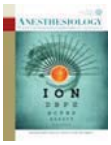
- None of these were significant!

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)?

Post-operative Visual Loss: Strategies for Prevention

- 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

Murphy DF. Anesth Analg 1985; 64:520-30
Cheng MA, Todorov A. et al, Anesthesiology 2001; 95:1351-5
Draeger J, Hanke K. Ophthalmic Res 1986; 18:55-60
Friberg TR, Weinreb RN. JAMA 1985; 253:1755-7

  Use padded headrest without pressure on eyes

Post-operative Visual Loss: Strategies for Prevention

Elevate the head of the bed to prevent edema formation

Stambough JL, Dolan D, et al. J Am Acad Orthop Surg 2007; 15(3):156-65

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?

Endorsed by North American Neuro-Ophthalmology Society and North American Spine Society

BUT

Is Staging Safer Than A Single Surgery?

Passias PG, Ma Y, et al. *Spine* 2012; 37:247-55

- 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

Patil CG, Lad EM, et al. Spine 2008; 33(13): 1491-6

- Avoid direct pressure on globe
- ~~Avoid perioperative hypotension~~
- ~~Avoid perioperative anemia~~
- Consider 10 degrees of reverse trendelenberg 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 N_2O:

N_2O 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

Can we prevent post-operative vision loss?

MAYBE,

But there is still a lot we do not know!