Postoperative Vision Loss

Kathy Alwon, MSN, CRNA

Objectives

- Investigate incidence of POVL
- Review anatomy and physiology of the eye
- Compare normal blood flow to the optic nerve versus compromised flow
- Discuss the relationship between ocular perfusion pressure, intraocular pressure, and mean arterial pressure
- Identify surgical procedures, surgical and patient factors that are associated with postoperative vision loss
- Discuss interventions that can reduce intraocular pressure

POVL Incidence

- First report of POVL incident: 1948[1]
  - Bailey headrest
  - Prone neurosurgical procedure
  - Cause: extraocular pressure



Incidence

- Overall: 1/60,000 - 1/125,000 anesthetics [Roth(2009)]

- Cardiac: 8.64/10,000 (0.0864% incidence) [Shen(2009)]
- Spine: 1 to 10/10,000 cases[2] (0.01-0.1% incidence)[2016]
- Appendectomy: 0.12/10,000 cases (0.0012% incidence) [Shen(2009)]

POVL Incidence Decreasing

Perioperative Visual Loss in Spine Fusion Surgery

Ischemic Optic Neuropathy in the United States from 1998 to 2012 in the Nationwide Inpatient Sample

Daniel S. Rubin, M.D., Isaac Parakati, B.S., Lorri A. Lee, M.D., Heather E. Moss, M.D., Ph.D., Charlotte E. Joslin, O.D., Ph.D., Steven Roth, M.D., F.A.R.V.O.

Anesthesiology 2016; 125:457-64

Volume of spine surgeries increasing

Year	Spinal Fusion Cases (n)
1998–2000	262,279
2001–2003	399,773
2004–2006	492,133
2007–2009	623,434
2010–2012	733,454
Total	2,511,073

Rubin. Anesthesiology. 2016.

Overall Incidence ION

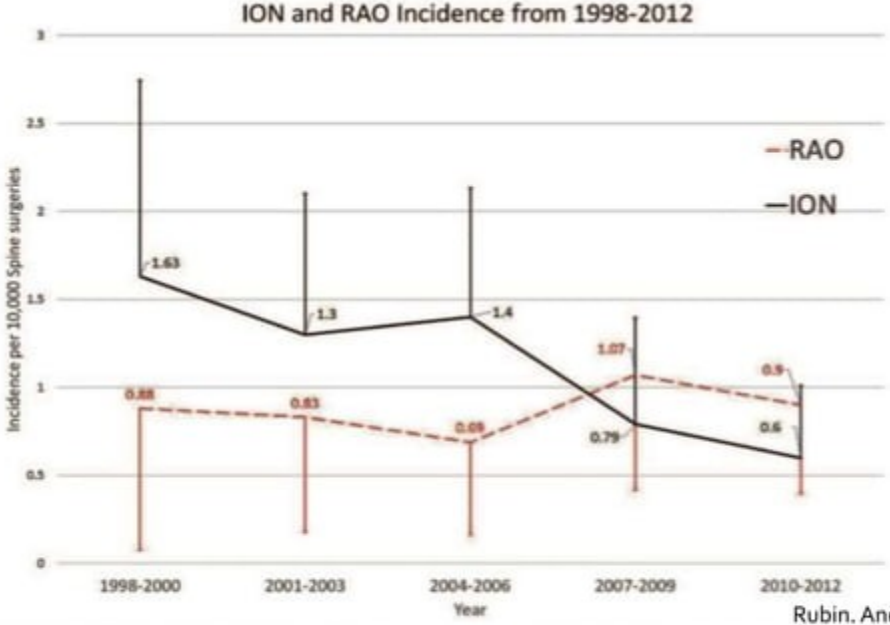
Year	ION per 10,000 Spinal Fusions (95% CI)
1998–2000	1.63 (0.57–2.75)
2001–2003	1.30 (0.48–2.10)
2004–2006	1.40 (0.65–2.13)
2007–2009	0.79 (0.18–1.40)
2010–2012	0.60 (0.18–1.01)
Total	1.02 (0.72–1.32)

Rubin. Anesthesiology. 2016.

Overall Incidence CRAO

Year	RAO per 10,000 Spinal Fusions (95% CI)
1998–2000	0.88 (0.076–1.72)
2001–2003	0.83 (0.18–1.50)
2004–2006	0.69 (0.16–1.24)
2007–2009	1.07 (0.42–1.67)
2010–2012	0.90 (0.40–1.42)
Total	0.89 (0.60–1.18]

Rubin. Anesthesiology. 2016.



Rubin. Anesthesiology. 2016.

Fig. 1. The y-axis shows the 3-yr incidence of ischemic optic neuropathy (ION) and retinal artery occlusion (RAO) per time period (x-axis), using national estimates from the Nationwide Inpatient Sample. The data are shown as incidence point estimates ± 95% CIs. Three-year periods were used, as Agency for Health Research and Quality does not allow reporting results less than 10. The

POVL Increases Hospital Cost & LOS

- Cost: $22,697 vs. $49,532
- LOS: 4.1 days vs. 8.6 days

Patient characteristics and outcomes of visual loss after spinal fusion surgery (ACF, PCF, ALF, PLF, thoracic)

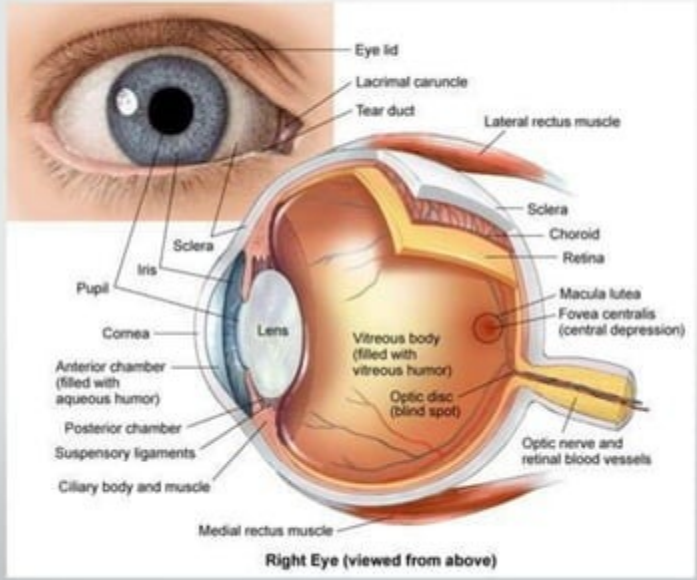
Characteristic/outcome	No visual loss (N=541,380)	Visual loss* (N=105)	p Value
Average age, y	52.4	37.6	
Age group, y; %			<.0005
18–44	29.6	51.4	
45–64	47.7	25.7	
65–74	15.0	14.3	
>75	7.7	8.6	
Gender, % female	53.4	46.7	.23
Race, %			
White	82.3	80.0	.40
Black	7.8	3.1	
Hispanic	5.8	12.3	
Asian	1.2	1.5	
Native American	0.4	0.0	
Other	2.5	3.1	
Charlson Comorbidity index	2.27	2.97	<.0005
Deformity surgery, % of total	6.0	56.2	<.0005
No. of levels, %			
1–2	81.7	39.0	<.0005
3–7	15.9	14.3	
≥8	2.4	46.8	
Length of stay, d	4.1	8.6	<.0005
Cost, $US	22,697	49,532	<.0005
Mortality, per 1,000 cases	3.0	0.0	.57

ACF, anterior cervical fusion; ALF, anterior lumbar fusion; N/A, not applicable; PCF, posterior cervical fusion; PLF, posterior lumbar fusion; POVL, perioperative visual loss.

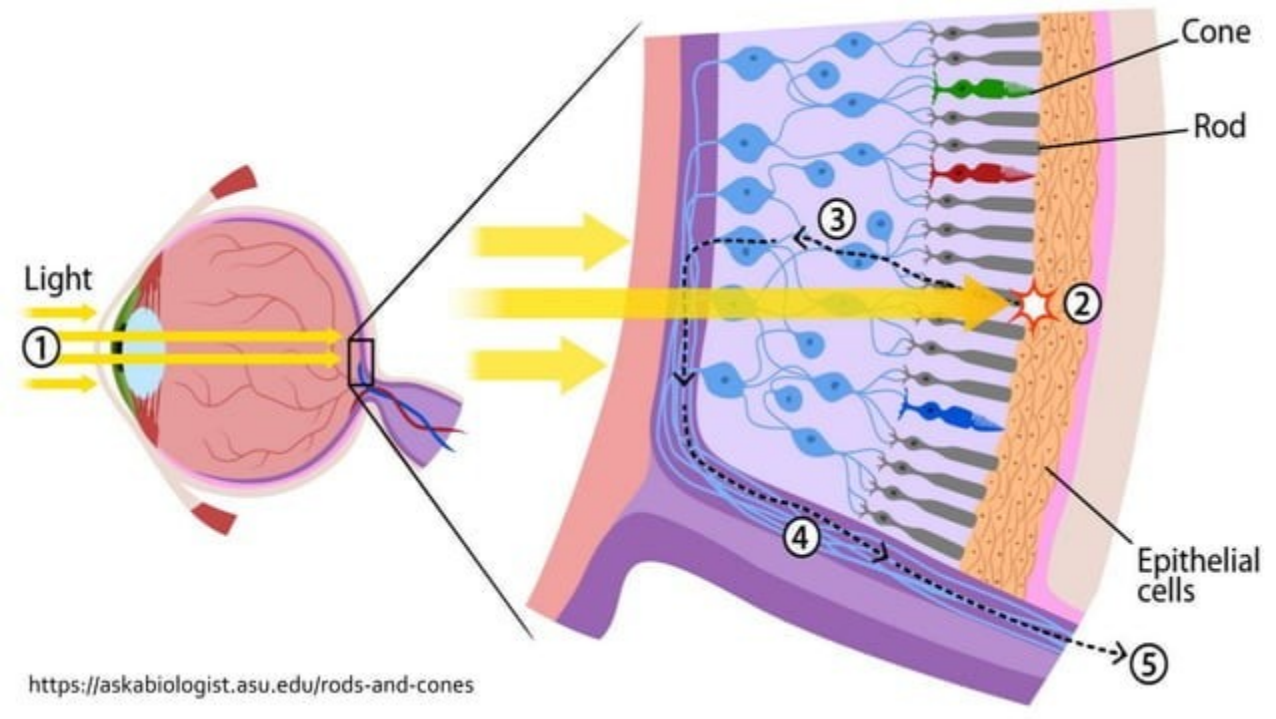
* Visual loss incidence per 10,000 patients is 1.9.

Nandyala. 2014. Spine J.

Eye Anatomy & Physiology



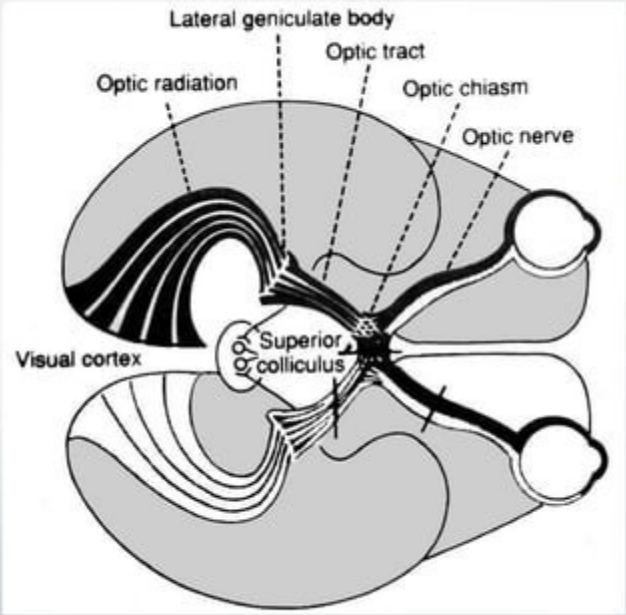
http://www.columbiaeyeclinic.com/anatomy-eye/


Light
1
Cone
Rod
2
3
4
5
Epithelial cells
https://askabiologist.asu.edu/rods-and-cones

Optic Chiasm

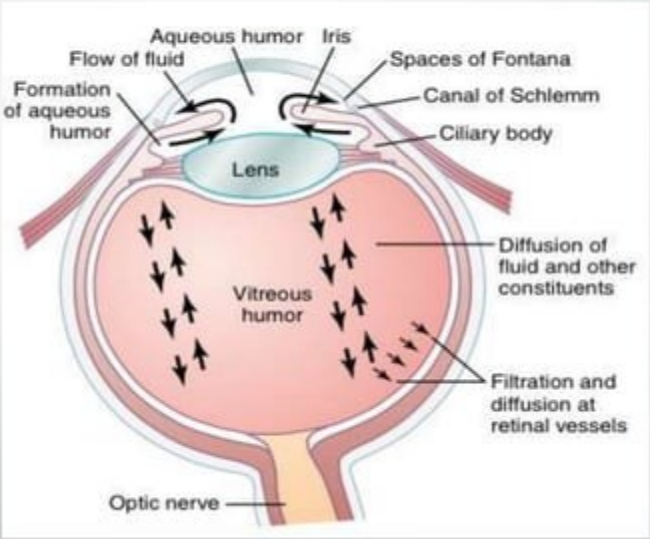
Lateral Geniculate Body

Visual Cortex



Aqueous Humor

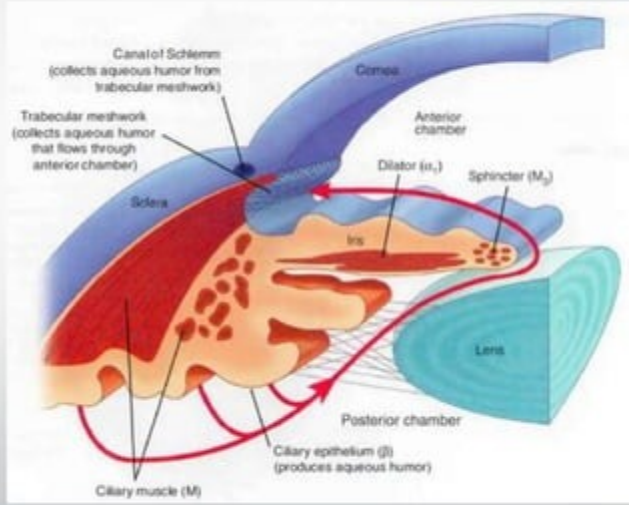
- Formed by ciliary process
- Continuously formed
- Enters space between lens and iris



Aqueous Humor Reabsorption

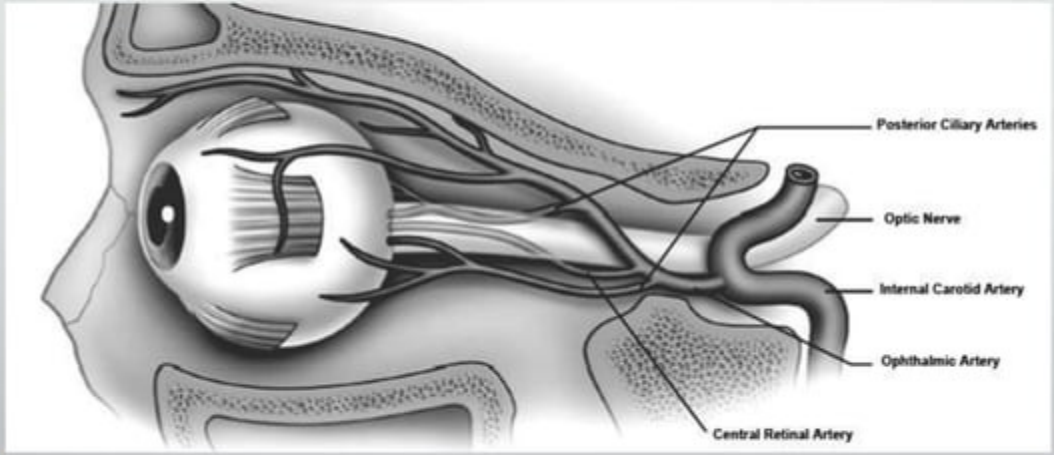
Canal of Schlemm → Trabecular Meshwork → Extraocular Veins

Reabsorbed at a rate of
2 - 3 µL/min

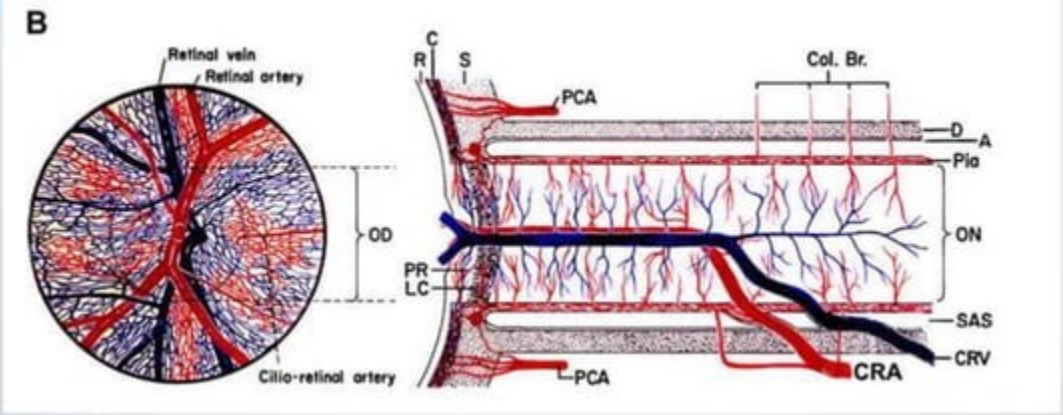


http://www.medicalopedia.org/

Blood supply to Optic Nerve



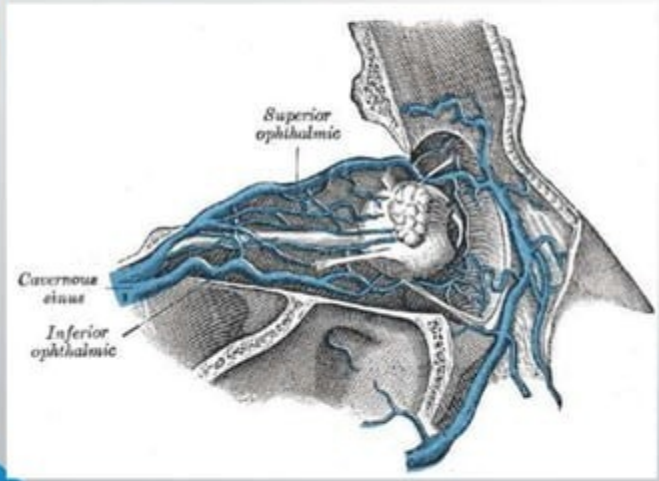
http://www.mallbao.cn/



http://webeye.ophth.uiowa.edu/

- PCA = Posterior Ciliary Arteries
- CRA = Central Retinal Artery
- CRV = Central Retinal Vein
- Col Br. = Penetrating Pial Arteries (collateral branches)

Venous Return



Central Retinal Vein

↓

Ophthalmic Vein
- Superior
- Inferior

↓

Internal Jugular Vein

Types of POVL

- Ischemic Optic Neuropathy (ION)
  - Anterior Ischemic Optic Neuropathy (AION)
  - Posterior Ischemic Optic Neuropathy (PION)
- Retinal Ischemia
  - Central Retinal Artery Occlusion (CRAO)
  - Branch Retinal Artery Occlusion (BRAO)

Ischemic Optic Neuropathy Hayreh 2011

Anterior Ischemic Optic Neuropathy (AION)

- Blood flow disrupted to anterior portion of optic nerve
- Optic disc edema, reduced pupillary light reflex
- More common to present with cardiac surgery

Posterior Ischemic Optic Neuropathy (PION)

- Ischemia to posterior portion of optic nerve
- Initial exam normal - delayed optic disc atrophy and pallor
- More common to present with spine surgery

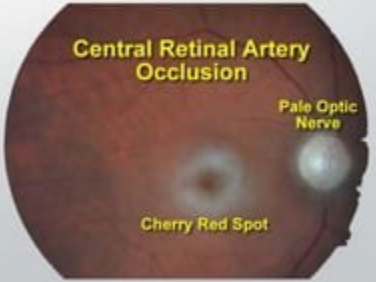
Retinal Ischemia Roth(2009)

Central Retinal Artery Occlusion (CRAO)

- Decreased blood supply to entire retina
- Most commonly from improper positioning & external compression to eye
- Pale edematous retina; cherry red spot to macula

Branch Retinal Artery Occlusion (BRAO)

- Most commonly associated with micro emboli
- Permanent partial visual field loss

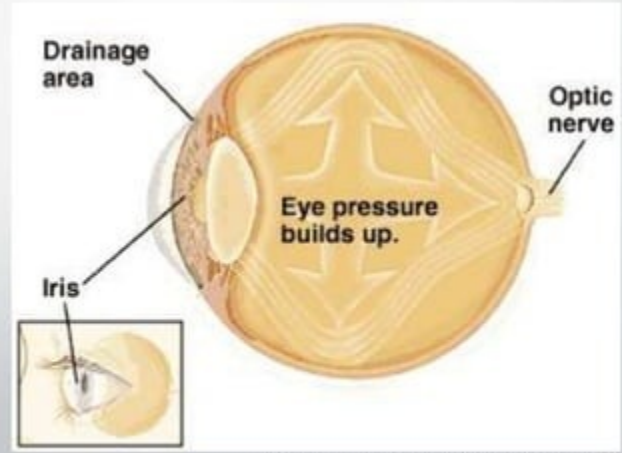


http://retinavitreous.com/diseases/raostart.php

Intraocular Pressure (IOP)

Normal range: 12-20 mmHg
Average: 15 mmHg

- IOP > 40 = decreased blood flow
- Regulated by the rate of aqueous humor entering and leaving the eye



http://www.floridalionsfoundation.org/Glaucoma.html

Ocular Perfusion Pressure

OPP = MAP – IOP

MAP: Mean Arterial Pressure

IOP: Intraocular Pressure

OPP primarily determined by IOP, not MAP Boltz 2013



http://www.reichert.com/

Measuring IOP



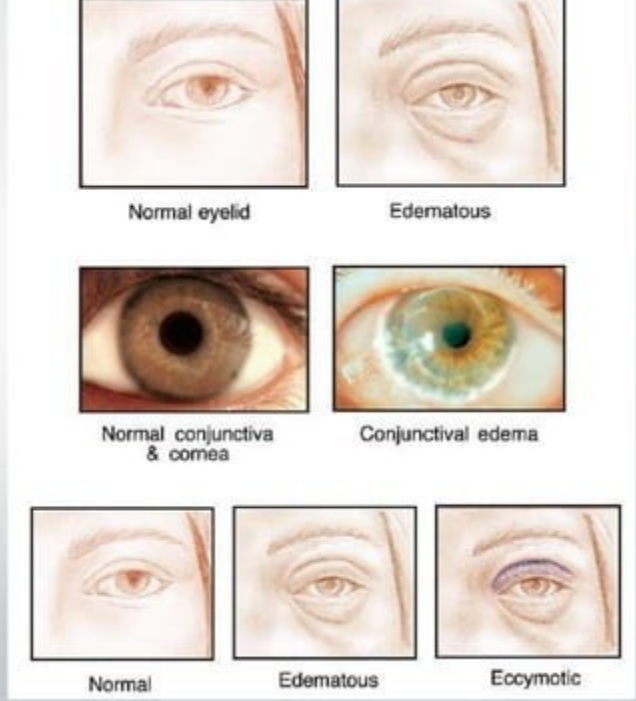
http://www.cmi.sk

Molloy/Bridgeport Anesthesia Associates Observation Scale[9]

Ocular edema: IOP is 2.5 times baseline pressure

Conjunctival edema (chemosis): IOP is 3.4 times baseline pressure

Ecchymosis: IOP is 4.3 times baseline pressure



Molloy. A preventative intervention for rising intraocular pressure. 2012. AANA.

Chemosis



https://drkotlus.com

Conjunctival edema



http://www.eyedoctom.com/EyeInfo/Chemosis.htm

Conjunctival edema (chemosis)	Baseline IOP (mm Hg)[a]	Probability (%)
0	5	14.6
0	10	33.8
0	15	78.3
0	20	100.0
0	25	100.0
1	5	100.0
1	10	100.0
1	15	100.0
1	20	100.0
1	25	100.0

Table 5. MBOS: Baseline IOP Probabilities of Reaching IOP > 40 mm Hg (Critical Threshold) in Steep Trendelenburg Position

Abbreviation: MBOS, Molloy/Bridgeport Anesthesia Associates Observation Scale; IOP, intraocular pressure.

[a] Preoperative baseline value in a high-risk population.

Probability of baseline IOP reaching above 40 mmHg (in steep T-burg) based on baseline IOP pressure[9]

Molloy. A preventative intervention for rising intraocular pressure. 2012. AANA.

Molloy/Bridgeport Scale[9]

Presence of chemosis alone, without a baseline IOP was predictive of IOP greater than 40 mmHg

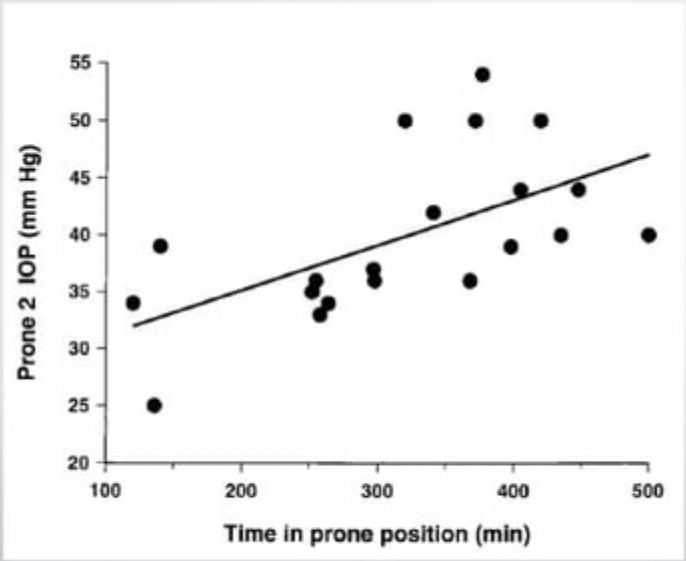
&

Chemosis correlates to IOP 3.4 times greater than the baseline value

Prone Position and Intraocular Pressure[15]

	Average IOP (mmHg)	Timing of Measurement
Baseline	19 +/- 1	Before induction
Supine 1	13 +/- 1	10 minutes after induction
Prone 1	27 +/- 2	Before Incision
Prone 2	40 +/- 2	At conclusion of surgery
Supine 2	31 +/- 2	Before reversal and emergence

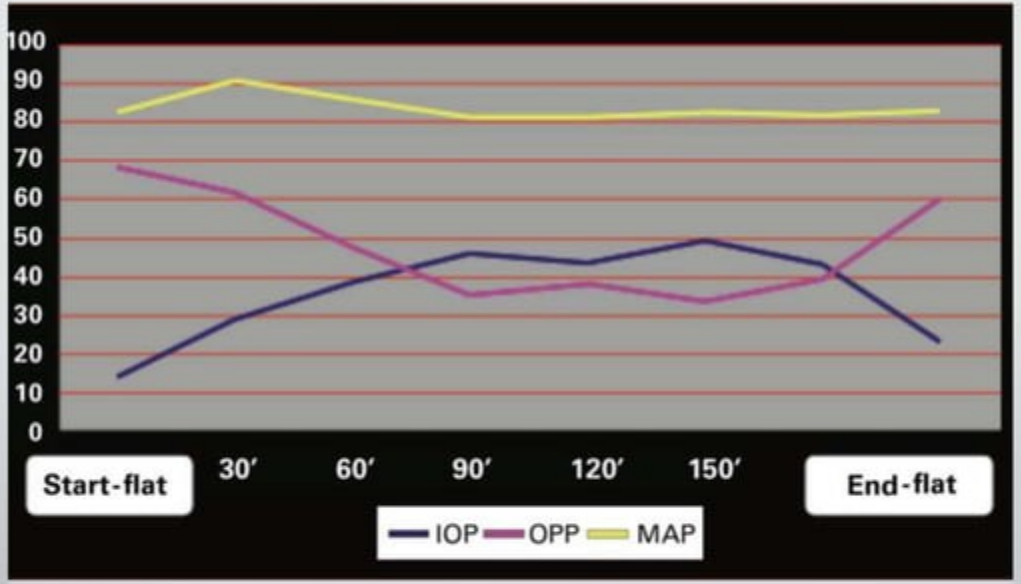
Cheng MA, et al. The effect of prone positioning on intraocular pressure in anesthetized patients. *Anesthesiology*. 2001.



Cheng MA, et al. The effect of prone positioning on intraocular pressure in anesthetized patients. *Anesthesiology*. 2001.

Steep Trendelenberg Position and Effects on IOP[6]

IOP Measurement (min)	Position	IOP (mmHg)
Initial	Flat (supine)	14 +/- 4
30	ST	25 +/- 8
60	ST	35 +/- 10
90	ST	35 +/- 8
120	ST	35 +/- 10
Final	Flat	21 +/- 6



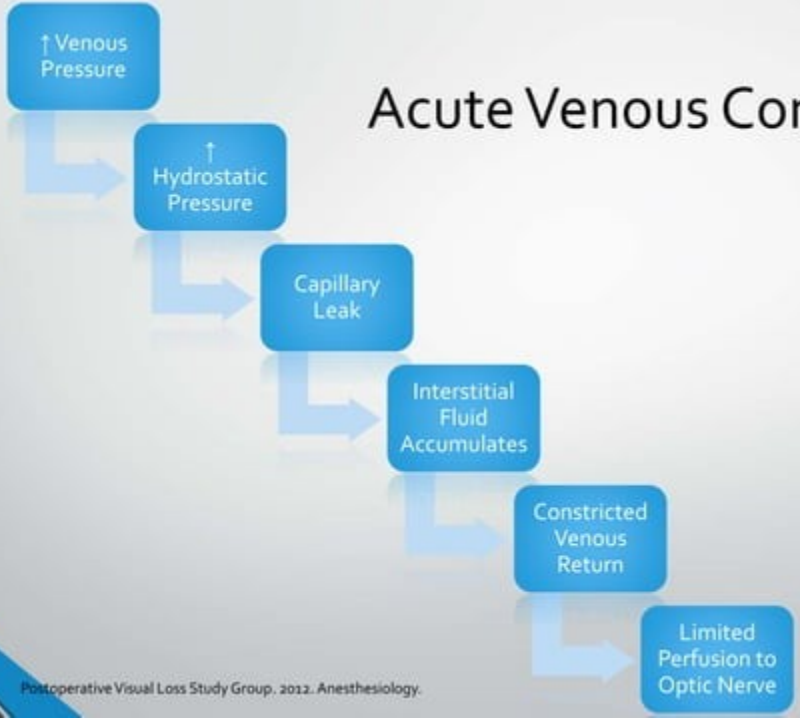
In 26% of patients, OPP dropped below IOP

Cause of POVL… multiple theories

- Acute Venous Congestion
- Compartment Syndrome of Optic Nerve



Acute Venous Congestion[1,11]



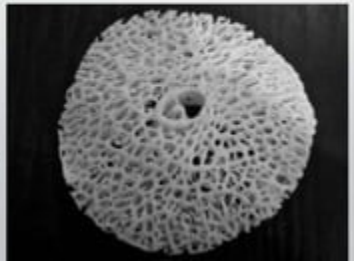
Postoperative Visual Loss Study Group. 2012. Anesthesiology.

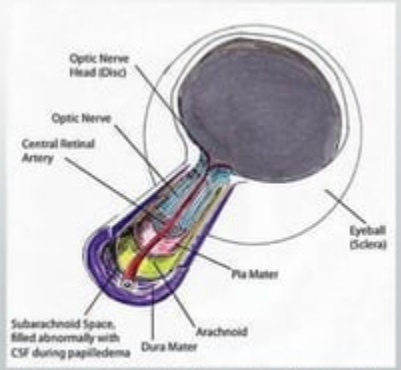
Compartment Syndrome of Optic Nerve[11]

Increased venous pressure + Interstitial fluid accumulation = Compromised blood flow

- Non-distensible space
  - Semi-rigid lamina cribrosa at the optic nerve head
  - Bony optic canal

Lamina Cribrosa





Postoperative Visual Loss Study Group. 2012. Anesthesiology.

Surgical Procedures Associated with POVL [11,12]

- Spine Surgery 0.2%
- Cardiac Surgery 4.5%



"Whoa! Watch where that thing lands - We'll probably need it."

Contributing Factors[10]

Length of Surgery

> 6 Hours



Figure 1. Photograph demonstrating traditional open posterior wound for segmental fixation.

Postoperative Visual Loss Study Group. 2006. Anesthesiology.

http://www.practicalpainmanagement.com

Contributing Factors[10]



http://www.rocketswag.com

EBL

> 1000 mL

Postoperative Visual Loss Study Group. 2006. Anesthesiology.

Contributing Factors[11,13]

- Prone Position
- Steep Trendelenberg Position





Contributing Factors[11]

Wilson Frame







Contributing Factors[14]

Excessive fluid replacement

- Lower percent colloid administration





Contributing Factors[1,11]

2015



Obesity

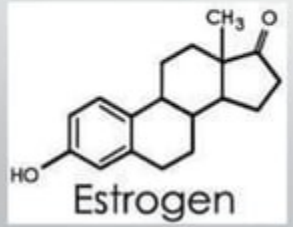
Postoperative Visual Loss Study Group. 2012. Anesthesiology.

https://www.cdc.gov/

Contributing Factors[1,11]

Higher incidence in males





Postoperative Visual Loss Study Group. 2012. Anesthesiology.

Contributing Factors

Extraocular Pressure[4]





Levan 2012

Prior to incision – proper positioning in headrest

Extraocular Pressure



Levan 2012

After 2 hours in prone position – face has migrated

Extraocular Pressure



Levan 2012

After 2.5 hours – nose in contact with headrest support



Extraocular Pressure

Levan 2012

Face repositioned to take pressure off eyes and nose

Contributing Factors… Recent Literature[1]

- Aging
- Male sex
- Transfusion
- Obesity

- Female sex was protective

Perioperative Visual Loss in Spine Fusion Surgery

Ischemic Optic Neuropathy in the United States from 1998 to 2012 in the Nationwide Inpatient Sample

Daniel S. Rubin, M.D., Isaac Parakati, B.S., Lorri A. Lee, M.D., Heather E. Moss, M.D., Ph.D., Charlotte E. Joslin, O.D., Ph.D., Steven Roth, M.D., F.A.R.V.O.

Rubin. Anesthesiology. 2016.

NOT Contributing Factors

- Hypotension[11]
- Intraoperative anemia[11]
- Pre-existing disease[1]:
  - Diabetes Mellitus
  - Hypertension
  - Coronary Artery Disease
  - Stroke
- Smoking[1]



Interventions to consider

Consult ophthalmologist at first sign that patient has altered vision after surgical procedure



Interventions to consider



Discuss with patient pre-op the risk of POVL, obtain informed consent

Interventions to consider

5° to 10° reverse T-burg during spine procedures in prone position



Interventions to consider



Limit excessive crystalloid administration

Interventions to consider

Stage lengthy spine procedures



Figure 1. Photograph demonstrating traditional open posterior wound for segmental fixation.

Interventions to consider

- Assess and document the eyes are free of pressure throughout prone procedure
- Use soft foam headrest with eye cutouts to prevent direct external compression; use a mirror to view the eyes





Interventions to consider

During ST procedures, use a 5 minute supine rest stop at the 4 hour timeframe.

This will require undocking laparoscopic equipment



	ST Group			Supine Group		
IOP/Time/Position	M	SD	Range	M	SD	Range
IOP – Initial (Flat)	13.4	4.73	9-26	13.2	4.15	8-24
IOP – 30 (Tburg)	25.1	7.76	11-33	21.1	5.43	8-35
IOP – 60 (Tburg)	32.3	10.06	23-57	24.5	7.58	11-40
IOP – 90 (Tburg)	33.8	8.23	25-51	20.5	7.08	6-43
IOP – 120 (Tburg)	35.7	10.56	25-61	18.7	5.22	10-33
IOP - Final (Flat)	20.6	4.58	10-42	14	4.69	7-24

Molloy B, Watson C. A comparative assessment of intraocular pressure in prolonged steep Trendelenburg position versus level supine position intervention. *Journal of Anesthesiology & Clinical Science.* 2012;1:9

Intervention to consider

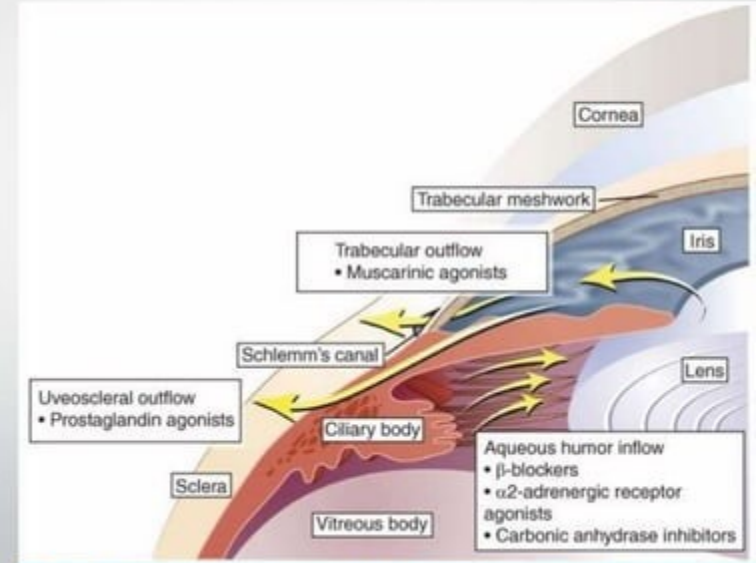
Use of dorzolamide hydrochloride/timolol maleate (COSOPT) ophthalmic solution



- Carbonic anhydrase II inhibitor
- β- adrenergic receptor blocker
- 1 mL COSOPT contains
  - 20 mg dorzolamide
  - 5 mg timolol

Intervention: COSOPT

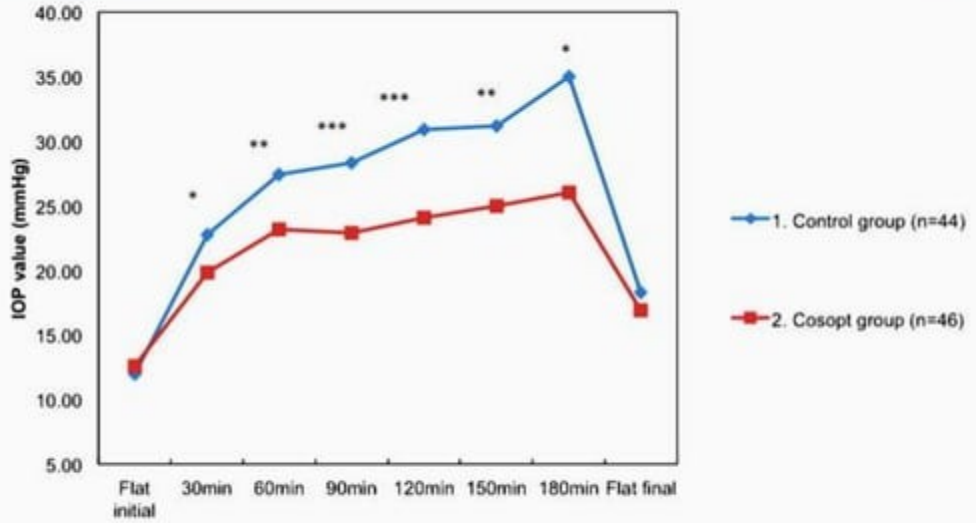
- **Reduces IOP by decreasing the production of aqueous humor**
- Inhibits carbonic anhydrase II in the ciliary process
- Direct action blocking β-adrenergic receptors in the ciliary process



Considerations when using COSOPT

Delivered topically but absorbed systemically

- Contraindications:
  - Reactive Airway Disease
  - Asthma
  - Severe COPD
  - Sinus Bradycardia
  - AV Block
  - Overt cardiac failure
  - Sulfa Allergy (contains sulfonamide)
- Caution
  - Diabetes
  - Hyperthyroidism (masks thyrotoxicosis)
- Adverse Reactions
  - Taste perversion (bitter, sour, unusual taste)
  - Blurred vision/eye itching



Molloy. 2016. AANA.[17]

Recommendations

- 5-10 degree Reverse Trendelenberg when prone
- Stage lengthy spine procedures
- Prevent direct compression to eye
- Utilize colloids, limit crystalloid
- At 4 hours: rest period for Steep Trendelenberg (5-10 min)
- Use of COSOPT in high risk patients or presence of chemosis
- Provide patients with informed consent regarding POVL

Questions?



References

1. Slocum HC, O'Neal KC, Allen CR. Neurovascular complications from malposition on the operating table. *Surg Gynecol Obstet.* 1948;86(6):729-734.
2. Rubin DS, Parakati I, Lee LA, Moss HE, Joslin CE, Roth S. Perioperative visual loss in spine fusion surgery: Ischemic optic neuropathy in the United States from 1998 to 2012 in the nationwide inpatient sample. *Anesthesiology.* 2016; 125(3): 457-464.
3. Levan P, O'Rourke M, Presta M, Byram S. The use of mobile smartphone technology to enhance positioning of a prone patient for thoracic spine surgery. *IJA.* 2012;30(3):1-4.
4. Roth S. Perioperative visual loss: what do we know, what can we do? *Br J Anaesth.* 2009;103(suppl I):i30-i40.
5. Hayreh SS. Management of ischemic optic neuropathies. *Indian J Ophthalmol.* 2011;59(2):12-136
6. Shen Y, Drum M, Roth S. The prevalence of perioperative visual loss in the United States: a 1—year study from 1996 o 2005 of spinal, orthopedic, cardiac, and general surgery. *Anesth Analg.* 2009;109(5):1535-1545.
7. Guyton AC, Hall JE. *Textbook of Medical Physiology.* 12th ed. Philadelphia, PA: Elsevier Saunders; 2011.
8. Postoperative Visual Loss Study Group. Risk factors associated with ischemic optic neuropathy after spinal fusion surgery. *Anesthesiology.* 2012;116(1):15-24.
9. Molloy B. A preventative intervention for rising intraocular pressure: development of the Molloy/Bridgeport Anesthesia Associates Observation Scale. *AANA J.* 2012;80(3):213-222.
10. Lee LA, Roth S, Posner KL, et al. The American Society of Anesthesiologists postoperative visual loss registry: analysis of 93 spine surgery cases with postoperative visual loss. *Anesthesiology.* 2006;105(4):652-659.
11. Lee LA, Roth S, Todd MM, Posner KL, Polissar NL, Neradilek MB, Torner J, Newman NJ, Domino KB. The Postoperative Visual Loss Study Group: Risk factors associated with ischemic optic neuropathy after spinal fusion surgery. *Anesthesiology.* 2012;116:15-24.
12. Grover VK, Jangra K. Perioperative vision loss: A complication to watch out. *Journal of Anaesthesiology Clinical Pharmacology.* 2012; 28(1): 11-16.
13. Molloy BL. Implications for postoperative visual loss: steep Trendelenburg position and effects on intraocular pressure. *AANA J.* 2011;79(2):114-121.
14. American Society of Anesthesiologists Task Force on Perioperative Blindness. Practice advisory for perioperative visual loss associated with spine surgery: an updated report by the American Society of Anesthesiologists Task Force on Perioperative Visual Loss. *Anesthesiology.* 2006;104(6):1319-1328.
15. Cheng MA, Todorov A, Tempelhoff R, McHugh T, Crowder CM, Lauryssen C. The effect of prone positioning on intraocular pressure in anesthetized patients. *Anesthesiology.* 2001;95(6):1351-1355.
16. Molloy B, Watson C. A comparative assessment of intraocular pressure in prolonged steep Trendelenburg position versus level supine position intervention. *Journal of Anesthesiology & Clinical Science.* 2012;1:9.
17. Molloy BL, Cong X, Watson C. Preventive dorzolamide-timolol for rising intraocular pressure during steep Trendelenburg position surgery. *AANA J. 2016;84(3):189-196*