Bleeding Is Not The Only Complication
What Other Minefields are Out There?

DANIEL JANIK, MD
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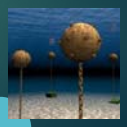
UNIVERSITY OF COLORADO
SCHOOL OF MEDICINE

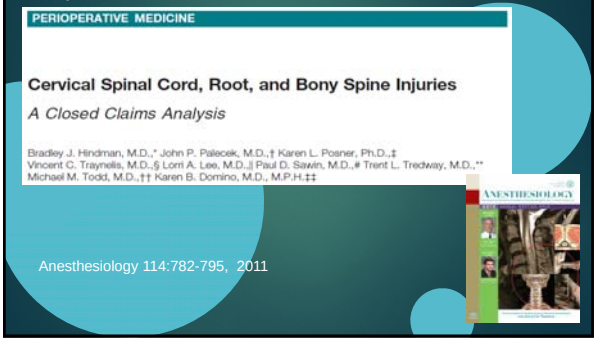


Degenerative Disease of the Spine May Place Patients at Risk in Absence of Instability

DISCLOSURE

I HAVE NO COMMERCIAL OR OTHER CONFLICTS OF INTEREST

Occult Risk of Perioperative Injury to The Cervical Spinal



PERIOPERATIVE MEDICINE

Cervical Spinal Cord, Root, and Bony Spine Injuries

A Closed Claims Analysis

Bradley J. Hindman, M.D.,* John P. Palecek, M.D.,† Karen L. Posner, Ph.D.,‡ Vincent C. Traynelis, M.D.,§ Lorri A. Lee, M.D.,‖ Paul D. Sawin, M.D.,# Trent L. Tredway, M.D.,** Michael M. Todd, M.D.,†† Karen B. Domino, M.D., M.P.H.‡‡

Anesthesiology 114:782-795, 2011

Positioning is Important!

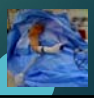
Where Are The Potential Risks?

A Closed Claims Search

- All general anesthesia claims from 1970-2007
- Cervical injury claims = 48 (1%)
- 69% were permanent and disabling compared to 19% for other general anesthesia claims
- 73% were male
- Cord injuries (n=37) were most severe and resulted in quadriplegia
- Cord injuries often occurred in absence of trauma (81%) or instability (76%)

Contributors to Cord Injury

- Anatomic abnormalities – 81%
- Direct surgical complications – 24%
- Preprocedure cord injury – 19%
- Intraoperative head/neck position – 19%
- Airway management – 11% ⬅ *Now that is interesting!*
- *Another interesting finding – 24% occurred in patients in the sitting position!*



Cervical Spondylosis

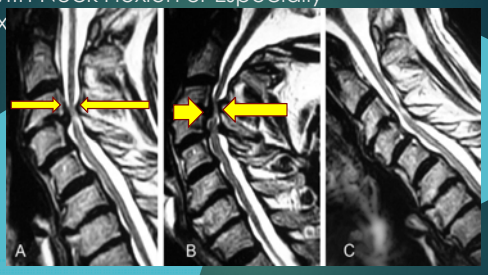
- 20-30% of patients age 40 have disc dessication, disc herniation, narrow intervertebral spaces

  Matsumoto M et. al., J Bone Joint Surg Br 80:19-24, 1998
- 10-30% of patients age 60 have evidence of root or cord compression

  Lee MJ et.al., J Bone Joint Surg Am 89:376-80, 2007
- Advanced cervical spondylosis can lead to canal stenosis and cord compression with myelopathy
- Severe cervical stenosis can be asymptomatic with no clinical signs

  Emery SE et. al., J Bone Joint Surg 80:941-50, 1998
- A chronically compressed cord has limited physiologic reserves and may be more prone to ischemia

Spondylotic Compression Can Increase With Neck Flexion or Especially Ex



Shedid D and Benzel EC, Neurosurgery 60:S7-13, 2007

What About Head Position?

- Of those claims where head position was judged to be contributory to injury, records showed the patient was:
  - in marked extension,
  - extension was possible,
  - or in extreme hyperextension

Can Neurophysiologic Monitoring Help?

Role of multimodal intraoperative neurophysiological monitoring during positioning of patient prior to cervical spine surgery

Julio Plata Bello [a,*], Pedro Javier Pérez-Lorensu [b], Héctor Roldán-Delgado [a], Liberto Brage [a], Verónica Rocha [a], Vanessa Hernández-Hernández [a], Ayoze Dóniz [a], Víctor García-Marín [a]

- 75 patients with severe cervical myelopathy IONM data collected from onset of positioning to end of surgery
- 5 alerts during positioning: 5 lost TcMEPs, 2 lost SSEPs as well
- 4 were repositioned with return of responses and no sequelae
- 1 did not and suffered tetraparesia post-op which did recover after 2 weeks of rehab
- *Clinical Neurophysiology 126 (2015)*

A Wee Bit of Trouble?

What About The Arms?

Take-away Message From This Study

- Degenerative changes which may put cervical spinal cord at risk for injury are common and may be clinically silent
- These changes limit the physiologic reserve of the cervical spinal cord
- Events under our control (positioning of the head, blood pressure, airway management) can have significant impact on patient outcome
- Beach chair position merits close attention (both head position and blood pressure)

CERVICAL SPINE CASE C3-T4 Scoliosis Correction

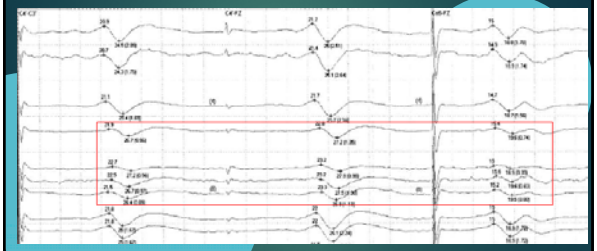
Another Take-Home Message

"We can take some comfort (though how much comfort is unclear) that contemporary anesthesiologists' efforts to avoid injury during laryngoscopy and endotracheal tube placement are paying off. However, we should be disturbed that there are other groups of heretofore unrecognized patients who are becoming injured, and for reasons that are not readily apparent"

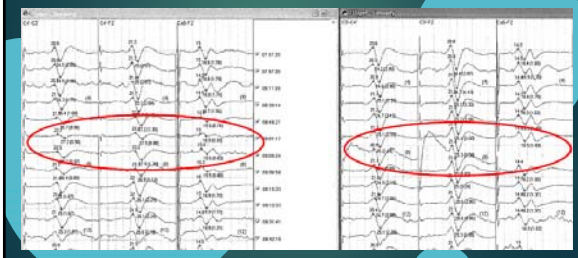
Lanier WL and Warner MA, Anesthesiology 114:729-31, 2011

C3-T4 Scoliosis Correction

Left Median Nerve SSEP



C3-T4 Scoliosis Correction
Median Nerve SSEP Stacks Left & Right

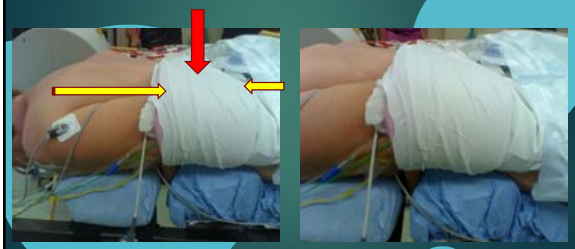


C3-T4 Scoliosis Correction

- What has happened?
- Is this an anatomic, physiologic, or technical problem?
- Where do you think the problem is?
- What would you do to investigate?
- Would you make any change in your management?

C3-T4 Scoliosis Correction
Left Transcranial Electric MEPs

C3-T4 Scoliosis Correction
Arm wraps with Arms Tucked at Side



C3-T4 Scoliosis Correction
Right Transcranial Electric MEPs

Lateral Decubitus

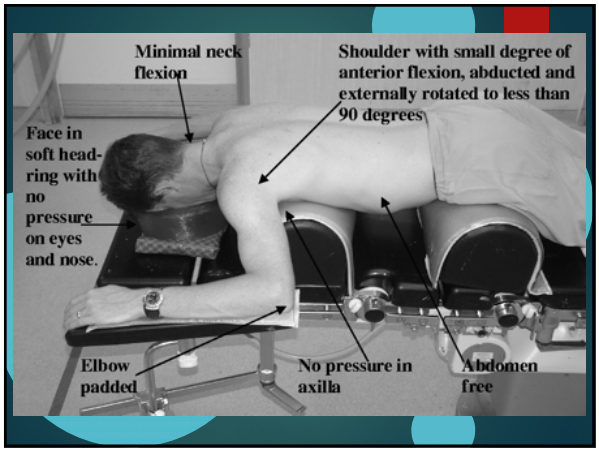
- Most common: Brachial, radial, median, ulnar
  - Radial nerve palsy of the upper arm
- Axillary Roll
  - Supports the thorax, protect brachial plexus from compression
  - Should be placed caudad to the axilla, on the rib cage
- Arm holder, or pillow placed between the two arms

Prone

- Most common: ulnar, radial and median
  - Brachial plexus can be compressed against the second rib secondary to force on the clavicle
- Upper limb should maintain a small degree of anterior flexion, and then abducted and externally rotated to less than 90 degrees.
  - If arm is hyperabducted, the humeral head can compress the brachial plexus
- Ensure chest support does not impinge the axilla
- Forearm pronated and supports/pads should be placed to prevent the indirect compression of the ulnar nerve or axial pressure from the humerus.
- Head and neck neutral

Recurrent Laryngeal Nerve Injury Following Anterior Cervical Spine Surgery

- Occurs in 0.2 – 24.2% of cases; may be subclinical
  - Fountas; Spine 2007
- Permanent hoarseness 2-4%
  - Jung; J Neurosurg Spine 2005
- Symptoms include:
  - Hoarseness
  - Dysphonia
  - Dysphagia
  - Vocal fatigue
  - Persistent cough
  - Aspiration
- If injury bilateral will cause airway obstruction requiring tracheostomy
  - Fountas; Spine 2007



Recurrent Laryngeal Nerve Injury Following Anterior Cervical Spine Surgery

- Surgical approach side has no impact on incidence
  - Kilburg; J Neurosurg Spine 2006
- 80% or more will recover in 12 months
  - Morpeth; Laryngoscope 2000
- Proposed mechanisms:
  - Surgical trauma
  - Nerve division or ligature
  - Pressure or stretch-induced neuropraxia
- Postoperative edema
  - Kriskovich; The Laryngoscope 2000

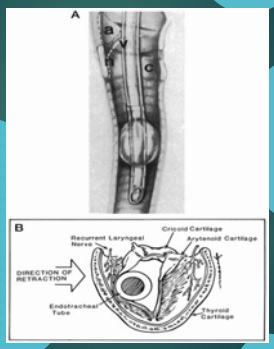
Do Your Surgeons Monitor Recurrent Laryngeal Nerve EMG?

RLN risk during anterior cervical spine procedures

Recurrent Laryngeal Nerve Injury Following Anterior Cervical Spine Surgery

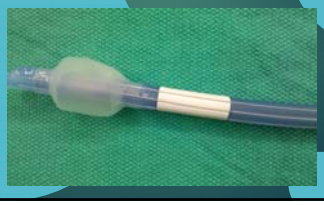
- Most common cause reported to be retractor displacement of the larynx against shaft of ETT with pressure on intralaryngeal segment of RLN
  - Kriskovich; The Laryngoscope 2000
- Conflicting studies whether deflation/reinflation of ETT cuff lowers incidence
  - Apfelbaum; Spine 2000
  - Audu; Anesthesiology 2006
- Found increased pharyngeal EMG activity on retractor insertion; correlated intubation time and ETT cuff pressure with post-op dysphonia and odynophagia
  - Jellish; J Neurosurg 1999

Vocal Fold Paralysis After Anterior Cervical Spine Surgery: Incidence, Mechanism, and Prevention of Injury

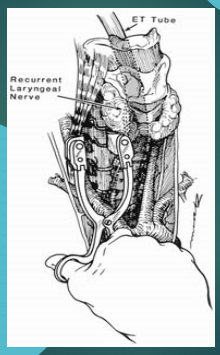


The Laryngoscope
Volume 1... pages 1467-1473, 2 JAN 2009 DOI: 10.1097/00005537-200009000-00011
http://onlinelibr... ...537-200009000-00011/full#fig2

Medtronics Xomed EMG Endotracheal Tube



Vocal Fold Paralysis After Anterior Cervical Spine Surgery: Incidence, Mechanism, and Prevention of Injury



The Laryngoscope
Volume 1... pages 1467-1473, 2 JAN 2009 DOI: 10.1097/00005537-200009000-00011
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Clin Orthop Relat Res (2016) 474:1019–1025
DOI 10.1007/s11999-015-4650-x
Clinical Orthopaedics and Related Research®
A Publication of The Association of Bone and Joint Surgeons®
CrossMark

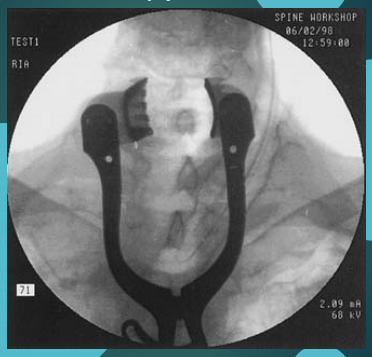
CLINICAL RESEARCH

Smoking is Associated with Increased Blood Loss and Transfusion Use After Lumbar Spinal Surgery

Peter T. McCunniff MD, Ernest S. Young MD, Kasra Ahmadinia MD, Uri M. Ahn MD, Nicholas U. Ahn MD

- 537 Lumbar decompression surgeries with or without fusion
- 317 (59%) nonsmokers
- 220 (41%) smokers
- Smoking history rounded to nearest 0.5 packs per day
- Smoking 1 PPD associated with 328 mL more operative blood loss ($p<0.001$)
- Relationship is linear
- Smoking associated with increased use of transfusion after surgery each PPD (OR 13.8)

Vocal Fold Paralysis After Anterior Cervical Spine Surgery: Incidence, Mechanism, and Prevention of Injury



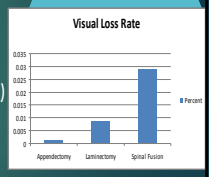
The Laryngoscope
Volume 1... pages 1467-1473, 2 JAN 2009 DOI: 10.1097/00005537-200009000-00011
http://onlinelibr... ...537-200009000-00011/full#fig4

What About The Eyes?

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



Non-hemorrhagic infarct in left occipital lobe

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

Most Common Causes

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

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

- 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

Ischemic Optic Neuropathy

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

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

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

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

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

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)

BUT

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

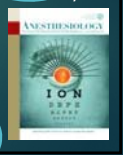
PRE-OP	INTRA-OP	POST-OP
Sex/BMI	Procedure	Facial edema
MAP	Duration/Position	Lowest MAP
Hgb/Hct	Lowest MAP	Lowest Hgb/Hct
HTN/Stroke	Lowest Hgb/Hct	Use of blood products
Smoking	EBL/Use of Products	
DM/Renal Dz	Vasopressor use	
MI/↑ Cholesterol	CPB duration	

- None of these were significant!

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

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

Post-operative Visual Loss: Strategies for Prevention

Lee LA *Curr Opin Anesthesiol 2013, 26:375-381*

- 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 or neutral

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

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?

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

Is Staging Safer Than A Single Surgery?

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

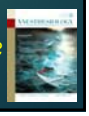
- Nationwide Inpatient Sample
- 1998-2006
- 11265 circumferential spine surgeries
- Increased incidence (28.4% vs. 21.7%) of complications including:
  - DVT
  - ARDS
- Age > 65 years old also increased risk

Proper positioning of ProneView™ Pillow

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 a-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?



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

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

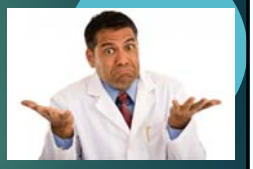
  Kempen PM Anesthesiology 2012; 117: 431-2
- Restrict crystalloid to 40 ml/kg total for spine case:

  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!

Potential Complications

- Delayed awakening
- Blurred vision
- Delayed hemorrhage
- Increased lung dead space
- Increased shunt fraction
- Decreased renal blood flow with oliguria or anuria
- Cerebral thrombosis
- Cerebral or cerebellar infarction
- Spinal cord infarction
- Retinal thrombosis
- Ischemic optic neuropathy

Would you lower a patient's blood pressure to help control bleeding? And, if so, how low would you be willing to go?

Potential Uses

- Prostate surgery
- Orthognathic surgery
- Spine surgery
- Total hip arthroplasty
- Shoulder surgery
- Head and neck surgery
- Intracranial procedures (aneurysm clipping)

Deliberate Hypotension

- Classic definition:
  A reduction in systolic blood pressure to 80-90 mmHg, or a decrease in MABP to 50 to 65 mmHg in normotensive patients.
- Almost all guidelines were developed for healthy, young patients

Efficacy in Orthopedic Procedures

- Subgroup analysis showed reduction in blood loss for:
  Total hip arthroplasty – 503 mL
  Spine fusion – 318 mL
  Orthognathic surgery – 147 mL
- Clinical significance depends on patient co-morbidities and surgical procedure

Review Article – Recommendations in Spine Surgery

- Contraindication: altered baseline autoregulatory mechanisms or vulnerability to ischemic complications
- Maintain SBP 20-30% below baseline values (80-90 mmHg) in ***normal*** patients
- Close monitoring of end-organ function
- Hypotension should be abandoned in presence of changes in nerve conduction studies (SSEP, MEP), EKG changes, decreased urine output, severe anemia (Hct < 20%), or tissue acidosis

Dutton RP, Eur Spine J (Supp) 13:S66-S71, 2004

Use of Deliberate Hypotension

- Selective use still advocated by some
- Proper patient selection
- Paired with procedures with proven efficacy
- Intense monitoring of end-organ perfusion
- Balance risks with benefits
- Maintain decreased MABP only as long as necessary
- Remember – the lower limit of cerebral autoregulation is higher than previously taught

In Conclusion

- Deliberate hypotension is considered an acceptable strategy to use to manage operative blood loss
- Careful patient selection is necessary to minimize risk
- It has been shown to significantly reduce blood loss and transfusion requirements in certain cases
- The lowest acceptable MABP must be individualized for each patient based on presence/absence of comorbidities and surgical position
- Close monitoring of end-organ perfusion is essential
- Maintain hypotension for as brief as necessary

Does the ASA Provide Any Guidance?


Anesthesiology 2006; 105:198–208 © 2006 American Society of Anesthesiologists, Inc. Lippincott Williams & Wilkins, Inc.

Practice Guidelines for Perioperative Blood Transfusion and Adjuvant Therapies

An Updated Report by the American Society of Anesthesiologists Task Force on Perioperative Blood Transfusion and Adjuvant Therapies

"When appropriate, intraoperative or postoperative blood recovery and other means to decrease blood loss (*e.g.* deliberate hypotension) may be beneficial."

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

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

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

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

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

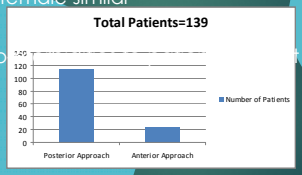
Nuttall GA et al, Anesthesia and Analgesia 2001; 93:1410-6

- 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

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

- Spinal fusion with visual loss:
  - ***83% posterior approach***
  - Male vs. female similar
  - Younger
  - Similar co t loss



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)

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