Open Globe Surgery

ANESTHETIC CONSIDERATIONS:

- Surgical emergency
  - Risk of blindness with ↑IOP and further extrusion of intraocular contents
- Potential Trauma and associated injuries
- Full stomach/aspiration risk
- Need to optimize IOP
- Considerations for ophthalmic surgery
  - Shared airway, immobility and analgesia, oculocardiac reflex, smooth emergence

ANESTHETIC GOALS:

- Minimize aspiration risk (prophylaxis, RSI)
- Avoid increasing intraocular pressure
  - Avoid coughing, straining, vomiting during induction and emergence
  - Blunt hypertensive response to laryngoscopy
  - Ensure deep plane of anesthesia
  - Consider avoiding sux
  - Avoid hypercarbia and hypoxemia

PATHOPHYSIOLOGY

- Intraocular perfusion pressure
  - IPP = MAP – IOP
    - High IOP impairs blood supply, leading to a loss of optic nerve function
- Normal IOP 10-22 mmHg
  - Varies by 1-2 mmHg with each cardiac contraction
  - Diurnal variation of 2-5 mmHg (higher value upon awakening)
  - Positional variation – 1-6 mmHg higher when supine
- IOP becomes atmospheric once eye cavity has been entered
  - A sudden decrease in IOP to atmospheric pressure (open eye) can cause rupture of choroidal vessels
  - Increases in IOP in setting of open globe can lead to hemorrhage, or prolapse and loss of intraocular contents (eg: vitreous), retinal detachment, and permanent vision loss
  - Smaller punctures have higher resistance to vitreous loss w/ changes in IOP
- 3 main factors influence IOP
  - External pressure on the eye
    - Muscle contraction – orbicularis oculi, extraocular muscles
    - Venous congestion – Trendelenburg position, cervical collar, overhydration, coughing, vomiting, straining, crying can ↑IOP by ≥40 mmHg
    - Orbital tumor
  - Scleral rigidity
  - Intraocular contents
    - Solid – intraocular tumor
    - Semisolid – lens, vitreous
    - Liquid – blood, aqueous humor
      - Changes in arterial pressure have lesser impact on IOP than changes in venous pressure
      - Rate of aqueous production vs outflow is the PRIMARY determinant of IOP
        - Determinants of aqueous humor production
          - $IOP = K\,[(\Pi_{AQ} - \Pi_C) + P_C]$
          - K= outflow coefficient, Π= osmotic pressure, P= hydrostatic pressure, AQ= aqueous, C= capillary
        - Determinants of aqueous humor outflow
          - $A = r^4\,(P_{IOP} - P_v) / (8\eta L)$
          - A= volume of aqueous outflow per unit time, r= radius of Fontana spaces, P= pressure, IOP= intraocular, V= venous, η= viscosity, L= length of Fontana spaces
- Effects of anesthesia on IOP
  - Laryngoscopy and intubation ↑IOP even in absence of any visible reaction to intubation
  - Hypoventilation, CO2 administration and hypoxemia ↑IOP
  - Hyperventilation and hypothermia ↓IOP
  - Inhalational anesthetics – ↓IOP
  - IV anesthetics
    - Barbiturates, benzodiazepines, opioids, and propofol ↓IOP
    - Etomidate – direct ↓IOP however drug-induced myoclonus hazardous in setting of ruptured globe
    - Ketamine – controversial effect on IOP; recent studies suggest that it does not significantly ↑IOP, however nystagmus and blepharospasm produced by ketamine undesirable in ophthalmic surgery
  - Muscle relaxants
    - Nondepolarizing agents – ↓IOP
    - Depolarizing agents (sux) – ↑IOP
      - Onset of IOP increase 1min, average peak 8mmHg w/in 1-4min and return to baseline w/in 7min

        - Efficacy of pretreatment w/ nondepolarizing NMB, acetazolamide, or propranolol controversial; none of these techniques consistently or completely block ocular HTN response.
        - Lidocaine 1.5mg/kg may offer protection from ↑IOP induced by sux (in addition to attenuating hemodynamic response to laryngoscopy)
        - Any sux-induced ↑ in IOP is usually dissipated prior to onset of surgery
            - However, must avoid or be especially cautious in setting of repeat strabismus surgery, as forced duction test does not return to baseline for 20-30min
        - Loss of vitreous from sux has never been reported
    - Ganglionic blockers (tetraethylammonium, pentamethonium, trimethaphan) ↓IOP
    - Acetazolamide – ↓IOP
    - Hypertonic solutions (dextran, urea, mannitol, sorbitol) – ↓IOP

HISTORY

- Trauma patient
    - Mechanism of injury – foreign body, laceration,
    - Associated injuries – skull and orbital fractures, intracranial trauma with SDH, thoracic or abdominal bleeding
- Last meal
- PMHx, medications, allergies

PHYSICAL

- ATLS primary and secondary surveys
- Airway – standard exam to anticipate difficulty of intubation
- Vital signs, CNS, CVS, RESP – standard

INVESTIGATIONS

- Determined by associated injuries and PMHx

OPTIMIZATION

- Aspiration prophylaxis
- Tetanus, antibiotics

ANESTHETIC OPTIONS

- Topical
    - Combined topical anesthesia and sedation has been reported for *selected* patients with open globe injury
- Regional (ophthalmic blocks)
    - Potential to extrude intraocular contents via pressure generated by LA
    - Regional techniques may be safe for *select* open globe injuries (more anterior and smaller wounds)
- General anesthesia
    - Most prudent as extent of injury often cannot be determined preoperatively
    - Aspiration prophylaxis and RSI in setting of full stomach

ANESTHETIC SETUP

- **Drugs**
    - Atropine (oculocardiac reflex)
    - Drugs to reduce IOP – acetazolamide, hypertonic solutions (mannitol)
- **Equipment**
    - Standard CAS monitors

MANAGEMENT OF ANESTHESIA

- **Requirements for ophthalmic surgery**
    - Akinesia/immobility
    - Profound analgesia
    - Minimal bleeding
    - Avoidance or obtundation of oculocardiac reflex
    - Control of IOP
    - Awareness of drug interactions
    - Smooth emergence with minimal coughing
- **Induction**
    - Require deep plane of anesthesia and profound muscle relaxation before airway manipulation to prevent HTN, coughing and straining with associated ↑IOP and associated risk of extrusion of intraocular contents
    - RSI with preoxygenation, opioid loading, large doses of iv anesthetic and muscle relaxant
        - Lidocaine – mild attenuation of hemodynamic response to intubation
        - Succinylcholine – modest ↑IOP
            - Efficacy of defasciculating dose controversial, however Barash states "certainly no one would disagree that succinylcholine *if unaccompanied by pretreatment with a nondepolarizing neuromuscular blocking drug* Is contraindicated in patients with penetrating ocular wounds and should not be give for the first time after the eye has been opened" and later quotes "succinylcholine with precurarization probably remains the most tenable compromise in the open eye-full stomach challenge"
        - Rocuronium – ↓IOP
            - 1.2-2mg/kg produces rapid intubating conditions, however may outlast duration of surgery

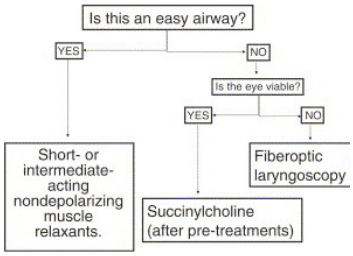

Fig.1 Intubation algorithm for open eye injuries.

        - Useful when sux contraindicated (MH, Duchenne muscular dystrophy, certain myotonias)
    - Inhalational induction suboptimal in setting of aspiration risk
    - Difficult airway
        - Consult w/ Ophthalmologist concerning probability of saving the injured eye
        - Consider avoiding GA – topical or regional anesthesia in select circumstances
        - Awake fiberoptic intubation may be safest option, recognizing that significant ↑IOP occurs w/ coughing or gagging, although these risks assume relative unimportance when balanced against risk of inability to oxygenate and ventilate the patient
            - Ensure thorough topical anesthesia of airway
            - Judicious sedation while maintaining oxygenation and avoiding hypoventilation
- **Maintenance**
    - Volatile agents or TIVA to maintain deep plane of anesthesia with no coughing or movement
    - Avoid ↑ing IOP – ensure adequate depth of anesthesia, avoid hypercarbia and hypoxemia, avoid volume overload, avoid Trendelenberg position, avoid mydriatic drugs
    - Monitor for oculocardiac reflex
- **Emergence**
    - Avoid coughing, vomiting, straining
        - Prophylactic antiemetics
        - Deep extubation not ideal in setting of aspiration risk
        - For awake intubation, ensure awake and adequate strength (avoid hypoventilation)
            - Lidocaine 1.5-2mg/kg or remifentanil before extubation to attenuate coughing

DISPOSITION & MONITORING

- Monitor for complications

COMPLICATIONS

- Oculocardiac reflex (OCR)
    - May occur during regional or general anesthesia
    - Incidence 16-82% - higher incidence in children (more vagal tone)
    - Triggers – pressure on globe, traction on EOM, conjunctiva, or orbital structures, retrobulbar block, ocular trauma, direct pressure on tissue remaining in orbital apex after enucleation
        - Hypercarbia, hypoxemia, and inappropriate anesthetic depth may ↑incidence and severity of OCR
    - Reflex arc – afferent limb trigeminal; efferent limb vagal
    - Manifestations – sinus bradycardia most common, arrhythmias (junctional, ectopic atrial, PVCs, wantering pacemaker, IVR, asystole, VT)
    - Prevention
        - Prophylactic anticholinergic drugs – im dosing ineffective, iv dosing may be effective however dose and timing controversial and may produce worse arrhythmias than the OCR
        - Retrobulbar anesthesia – may block afferent limb of reflex, however block itself associated w/ numerous complications including stimulation of OCR when performing block
        - Conclusion
            - Prophylactic measures are usually not indicated in adults
            - For pediatric strabismus surgery consider atropine or glycopyrrolate pretreatment
    - Treatment
        - Surgeon to cease operative manipulation → HR and rhythm usually return to baseline w/in 20sec
            - With repeated manipulation bradycardia less likely to recur due to fatigue of reflex arc at level of cardioinhibitory centre
        - If initial arrhythmia is especially serious or reflex recurs → administer atropine (after surgeon stops surgical manipulation)

REFERENCES

- Barash p. 891 and Chapter 51
- Miller Chapter 75
- Succinylcholine and the open eye. Ophthalmol Clin N Am. 2006;19:279-285