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Basic Principles

Anatomy

Key Points:
- Vitreous body
- Lens
- Aqueous humour - Ant & post chambers
- Iris
- Pupil
- Layered structures of eye:
  - Fibrous layer (outer):
    - Cornea & conjunctiva
    - Tenons capsule
      - = fibrous layer lying underneath conjunctiva
      - white & avascular
    - Sclera - 1mm thick
  - Uveal tract (vascular layer):
    - Choroid
    - Ciliary body
    - Iris
    - Pupil
  - Nervous layer (inner)
    - Retina
    - Optic disc
    - Macula

Bone
- pyramid shaped with apex pointing towards middle cranial fossa
- orbital rim overhangs structures to provide protection
- distance orbital rim ⇒ optic foramen = 42-54mm in adults
- volumes:
  - orbit = approx 30ml
  - globe & mm cone = 7ml
rest = connective tissue
• globe sits anterior, high and lateral in orbit
• optic nerve & large blood vessels found packed at apex of orbit
• boundaries:
  • medial walls - thin and parallel
  • lateral walls - define axis of orbit

**Globe**
• occupies ant part of orbit
• has an axial length of 20-25mm
  ➔ can be elongated in myopic individuals
• layers:
  • tenons capsule =
    - thin membrane which covers globe
    - extends from site of optic nerve to fuse with conjunctiva anteriorly
    - potential space =
      • contains ciliary nerves
      • rectus muscles - which penetrate tenons capsule
  • sclera

**Muscles**
• rectus muscles congregate at apex of orbit ➔ fibrotendinous ring
  • bands of connective tissue merge with rectus mms to form a conical structure aka muscle cone
    • within cone:
      - sensory nerves supplying globe
      - CN III & VI
        ➔ ✗ LA placed in cone will have rapid onset
    • outside fibrotendinous ring ✗ difficult to anaesthetise:
      • superior oblique mm (down & out)
      • elevator palpebral superioris (SNS supply)
    • orbicular oculi - innervated by VII - painful to block and does not improve surgery
**Nerves**

- optic nerve:
  - inserts into medial globe
  - travels medially in orbit to optic foramen
    \( \Rightarrow \) may be damaged by deep medial injections

- sensory innervation of eye:
  - sclera/cornea, upper lid & conjunctiva = trigeminal nerve (V1) \( \Rightarrow \) ophthalmic division \( \Rightarrow \) nasociliary nerve \( \Rightarrow \) long & short ciliary nerve
    \( \leftarrow \) enters orbit via superior orbital fissure \( \Rightarrow \) pierce fibrotendinous ring
  - lower lid & inferior conjunctiva = trigeminal nerve (V2) \( \Rightarrow \) maxillary nerve (inf orbital fissure & foramen)

- autonomic nerves:
  - ciliary ganglion lies in the cone:
    - afferent sensory via V1
    - PNS from the CN III (motor)
    - SNS from carotid plexus

- motor supply of orbit: \( (LR_6SO_4)_3 \)
  - VI \( \rightarrow \) supplies lat recturs mm (move eye lat)
  - IV \( \rightarrow \) supplies sup oblique mm (depresses eye when abducted)
  - III \( \rightarrow \) supplies all other eye movements incl eyelid elevation (levator palprabrae)

**Oculomedullary Reflexes**

- = oculocardiac, oculorespiratory and oculoemetic reflexes
- seen in 20-80% - esp paed squint surgery

- afferents: ciliary nerves \( \rightarrow \) ciliary ganglion \( \rightarrow \) trigeminal ganglion near floor of 4th ventricle
- efferents: vagus \( \rightarrow \) respiratory and vomiting centre

- triggers = traction of extraocular muscles, pressure on globe
- effects; bradycardia, sinus arrest, respiratory arrest, nausea
- prevention:
  - LA - abolish afferent arc
  - avoid hypercapnia - sensitises reflex
  \( \leftarrow \) NB glycopyrulate or atropine prophylaxis does not work
- reflex is fatiguable

**Blood Vessels**

- inferotemporal & medial parts of orbit are poorly supplied
  \( \leftarrow \) superonasal region is quite vascular
orbital structures get blood from:
- common carotid ⇒ internal carotid ⇒ ophthalmic artery
- ophthalmic artery enters orbit via optic canal within dural sheath of optic nerve
venous drainage:
- superior ophthalmic veins (via sup orbital fissure) ⇒ facial vein
- inferior ophthalmic veins (via inf orbital fissure) ⇒ connect with either sup orbital vein or cavernous sinus

**Physiology**

- any injection into orbit ⇒ ↑IOP ⇒ doming of vitreous into ant chamber
- LA will block afferent limb of oculo-cardiac reflex ∴ no bradycardia

**IntraOcular Pressure**

- normal 10-20mmHg
- content of eye:
  - aqueous humour (behind cornea)
  - vitreous humour (behind lens & in front of retina)
    - volume is relatively fixed ∴ not involved in IOP regulation
- increases with coughing, posture, vomiting and Valsava
- if IOP increases with globe open ⇒ vitreous extrusion, haemorrhage and lens prolapse
- aqueous humour:
  - total volume ~0.3ml
  - humour made in ciliary body of post chamber:
    - 2/3 = active - carbonic anhydrase dependant reaction (∴ inhibited by acetazolimide)
    - 1/3 = passive filtration from ant surface of iris
  - absorbed via trabecula meshwork ⇒ spaces of Fontana & venous canal of Schlemm trabecular meshwork
- Canal of Schlemm
  - located between iris & cornea at angle of ant chamber
  - obstruction of this ⇒ ↑IOP ⇒ damage to retinal nerves
    - ie glaucoma

**Factors increasing IOP**

- external pressure
  - eg from FM
  - blinking
  - haemorrhage
  - tumours
- pain eg laryngoscopy
- aqueous humour - ↓drainage
  - ↑venous pressure eg cough, strain
  - mydriasis - closes angle between iris & trabecular meshwork
- choroidal ↑ed blood volume:
  - ↑PaCO2 via vasoD
  - large ↑MAP
  - large ↓PaO2 ⇒ vasoD
- position: head down or prone
- drugs:
  - sux ↑10mmHg for 5-10mins (transient contraction of extraocular muscles & direct effects on choroidal blood volume)
  - large volumes of LA (transient)
  - ketamine

**Factors decreasing IOP**

- aqueous humour ↑drainage:
  - ↓ITP
  - head tilt up
- miosis
  - choroidal ↓ed blood volume:
    - ↓PaCO2 ⇒ vasoconstriction (PaCO2 26-30mmHg)
    - head up ⇒ ↑venous drainage
  - ↓ed external pressure:
    - NDNMBD
    - sub Tenons blocks
  - drugs:
    - mannitol (0.5g/kg -> withdrawal of fluid out of vitreous & ↓aqueous humour production)
    - acetazolamide (500mg IV -> reduces aqueous production by ciliary body)
    - β blocker - ↓production & miosis
    - muscarinic agonists - miosis ⇒ ↑drainage

Production and flow of aqueous humour in the eye.
Anaesthetic Concerns

Preoperative Assessment

- majority of ops done under LA
- most elderly with multiple co-morbidities
- if for GA -
  › should have routine 1x’s done
  › standard fasting protocols
- if LA:
  › modified assessment:
    - INR/APTT if on anticoags
    - BSL
    - ability to lie flat for 1hr
    - hearing/comprehension - able to follow instructions
    - anxiety level - ?for sedation
    - any hypoxic resp drive - unable to give fixed FiO2
  › no routine fasting ie light meal 2-3hr preop advised unless to be given LA & sedation
- routine 1x:
  › vitals
  › ECG - only if irreg pulse, CP, uncontrolled HTN, PM, syncope
- GA indications:
  › pt refusal of LA with full understanding of GA risks
  › major & lengthy operations eg vitreoretinal, corneal transplantation
  › prev retinal detachment surgery - sub Tenons contraindicated as possibly band placed around globe
  › unable to lie flat for 1hr (is option of deck chair position)
  › paeds
  › orbital involvement
  › multiple operation sites
- NSAIDs do not ↑ risk of retrobulbar haemorrhage

PeriOperative

- 2 major anaesthetic options:
  › aikinetik anaesthesia:
    - LA:
      • into extraocular mm cone = retrobulbar (aka intraconal block)
      • external to mm cone = peribulbar (aka extraconal)
      • Sub Tenon’s capsule
    - GA
  › kinetic analgesia
    - topical LA
    - supplemental intracameral injection of preservative free LA
    - subconj injection
- pre-op dilating (mydriasis) of pupils:
  › required for some surgeries
  › common agent =
    - cyclopentolate 0.5-1% (parasympatholytic)
    - phenylepherine 2.5% (sympathomimetic)
  › unusual to get SEs but HTN & APO have been reported
- intra-op dilation:
  › surgeon can inject subconjunctival mydricaine
    → mix of procaine, atropine & adrenaline

General Anaesthesia

Induction
- goals:
  › minimise ↑IOP
- maintain CVS stability
- avoid deep anaesthesia

LMA ideal:
- avoids laryngoscopy stimulation
- lighter anaesthesia - will be adjuncted with LA by surgeon

- if need to measure IOP post induction:
  - avoid standard IV induction agents - will ↓IOP
  - use either ketamine (IV or IM) or gas induction

ETT:
- need to ablate ↑IOP with laryngoscopy
  - opioid options:
    - fentanyl 5mcg/kg
    - fentanyl 2.5mg/kg & lignocaine spray to larynx
    - alfentanil 10-40mcg/kg
    - remi 1mcg/kg

Maintenance
- SV: for extraocular & minor surgery
- IPPV: control of CO2 - ↓IOP, ↓oculomedullary reflex
- avoid N2O
- TIVA ideal
- Sub-Tenons post induction by you or surgeon
- glycopyrolate prophylaxis

Extubation
- avoid coughing:
  - LMA easy
  - ETT -
    - spray cords with LA
    - deep extubation
    - lignocaine bolus at extubation
    - small dose of propofol
- watch for emergence HTN (& ↑IOP):
  - lignocaine bolus
  - esmolol
- avoid PONV
Eye blocks

- historical block = retrobulbar using 50mm needle
- now rare due to safety concern

Anticoagulation & Blocks

- warfarin patients:
  - Sub Tenons -
    - continue warfarin
    - safe to do block if in therapeutic range
  - Other blocks - need INR <1.5 ie Rx as neuraxial
- NOACs eg dabigitran/rivaroxiban:
  - no therapeutic range available .. must stop based on neuraxial guidelines

Modified Retrobulbar Block

- procedure:
  - topical LA
  - pt look straight ahead
  - 24mm, 25G needle inserted inferotemporally lateral to globe through conjunctival reflection
  - bevel of needle faces globe
  - needle aim straight backwards parallel to pyramid floor of orbit until reach back of globe (10-15mm)
  - then redirect slightly medially & upwards ⇒ into muscle cone at level of back of globe
  - must try not to cross medial to central axis of orbit as optic nerve runs here
  - aspirate ⇒ 4-5ml LA injected ⇒ pressure applied to eye
  - Ax akinesia @ 5min
  - may need supplementary blocks
- benefit:
  - excellent rapid ocular akinesia & analgesia for long operations
- risks:
  - high risk of serious complications eg
    - brainstem anaesthesia - subdural injection via optic nerve sheath
    - globe perforation (0.1-0.7%)
    - retrobulbar haemorrhage (1%)
    - optic sheath damage (0.25%)
Peribulbar Block

- procedure:
  - topical LA
  - pt look straight ahead
  - 16mm 25G needle inserted inferotemporally lateral to limbus through conjunctival reflection
    - historically 2 needle passes 2nd being superior nasal but assoc with ↑ bleeding
  - direct needle vertical backwards - on contact with bone then move needle slightly upwards
  - needle tip aim to be extraconal beyond equator of globe but ant to posterior border (peribulbar space)
  - aspirate ⇒ 5-10ml LA
  - apply light pressure to eye
  - if chemosis (conjunctive swelling): then reposition needle more deep

- benefits:
  - ↓ complications compared to retrobulbar
  - need to deposit LA close to muscle cone to achieve good akinesia

- disadv:
  - volume of LA ⇒ ↑ IOP (although short lived esp if use compression device)
  - ↓ed but still ↑ risk of serious complications (compared to sub Tenons):
    - globe perforation
    - retrobulbar haemorrhage

- relative Contraindications:
  - INR >2
  - axial length >26mm - eg severely myopic patients (short sightedness)
  - perforated or infected eye
  - unable to lie flat/still

Sub Tenons (episcleral) Block

- sub tenons = fascicle layer of CT surrounding globe & extraocular mm’s
- attached anteriorly to limbus of eye
- fuses with dura posteriorly around optic nerve
- usual mixture:
  - Average op: 50:50 split 2% leg & 0.5% bupiv & 150U hyalase
  - Fast cataract: 2% lig & 150u hyalase
  - Long viteroretinal: 1% rope & 150u hyalase

- procedure:
  - LA
  - iodine to conjunctiva
  - lid speculum to hold lids apart
  - pt looks up and outwards
  - inferonasal quadrant (5-7mm lateral from limbus): deep bite of conjunctiva & Tenons capsule is held up
  - horizontal opening made <2mm wide with spring scissors
  - should see tunnel disappearing into fornix
  - blunt dissection with scissors to 10mm
  - blunt curved 19G 25mm sub tenon’s cannula passed into tunnel following curve of sclera
  - aim for tip to be vertical depth 15-25mm post to equator of globe
aspiration ⇒ install 3-6ml LA (2% lignocaine) with gentle rotation in long axis
⇒ depending on size of orbit
gentle external pressure to eye for few minutes

• ↑ ed risks of:
  ➔ chemosis (40%)
  ➔ subconjunctival haemorrhage (30-50%)

• contraindications:
  ➔ prev glaucoma surgery
  ➔ buckle repair retinal detachment surgery with banding

• benefit:
  ➔ good for posterior eye surgery
  ➔ v low risk of serious complications
  ➔ painless
  ➔ no seperate CN VII block required
  ➔ safer in anti-coagulated patients

Intracameral Injection
- Performed by surgeon
- 0.1ml isotonic preservative free lignocaine
- injected into ant chamber
- provides anaesthesia to iris & ciliary body

Generic Regional Complications
• retrobulbar haemorrhage 1-2% incidence:
  ➔ catastrophic consequences
  ➔ ↑IOP ⇒ tamponade ⇒ ↓blood flow trough retinal artery ⇒ blindness
  ➔ inform surgeon immediately ⇒ immediate ↓IOP by lat acanthotomy
  ➔ signs:
    ➔ bleeding into skin & conjunctiva
    ➔ proptosis
    ➔ palpable ↑IOP
  ➔ NSAIDs do not affect risk
• globe penetration (<1%):
  ➔ may lead to:
    ➔ retinal detachment
    ➔ bleeding into vitreous
  ➔ signs:
    ➔ pain on injection
    ➔ sudden deviation
  ➔ more likely in myopic patients
• optic nerve damage (<1% incidence):
  ➔ ↑ed risk if
    ➔ retrobulbar injections made in medial compartment
    ➔ needle >25mm long
    ➔ gaze up and inwards during inferotemporal injections
  ➔ risk of permanent mechanical damage to optic nerve
  ➔ signs:
    ➔ pain
- sudden CNS toxicity

LA toxicity (uncommon)

- LA may be injected:
  - directly into inf orbital vein
  - into CSF via dural sheath of optic nerve
- need a LA toxicity Rx plan

Muscle palsies (uncommon)

- avoid direct injection into mm

Chemosis (common):

- swollen conjunctiva
- subsides with compression and time

Corneal abrasion:

- from compression device or post op from lack of eyelid movement

Systemic complications: oculomedullary reflexes, syncopal, seizures

**LA Drug Choices**

**Topical Drugs**

- topical drugs block nerve endings in cornea & conjunctiva only
  - intraocular & ant segment structures are not anaesthetised
  - why surgeon may add intracameral anaesthesia as an adjunct

Common vehicle choices are:

- viscous gels
  - lignocaine gel mixed with dilating meds, Abx & NSAIDs
  - eye drops

Considerations:

- corneal epithelial toxicity
- patient comfort
- allergies

Options:

- proparacaine
  - ester - but is not metabolised to PABA (metab‘ed by plasma esterase)
  - onset <20secs
  - lasts 15mins or longer
- tetracaine
  - most irritating
  - avoid if pt allergic
  - aka amethocaine
  - 0.5% or 1%
  - onset anaesthesia in 10-20secs; last 10 - 20mins (1% can last up to 1hr)
- lignocaine
- bupivacaine
- benoxinate (oxybuprocaine)
  - should not use in neonates
  - less irritating (less stingy) to conjunctiva than tetracaines
  - duration <1hr

High or prolonged doses can cause:

- toxicity to corneal epithelium ⇒ erosion & poor healing
- clouding of cornea

Alkalisation & warming LA to 37deg ⇒ ↓ latency & ↓ pain
Regional Drugs

![Image](image)

**Hyaluronidase**
- dilute 150 units into 7mls for sub-Tenons
- use is controversial
- has been shown in sub-Tenons (less evidence in other blocks) to
  - enhance speed of onset & quality of block
  - minimise the effect on ↑ing IOP
- works by promoting diffusion to periorbital & retro-orbital tissue
  - improves chance of akinesia by blocking facial nerve preventing need for painful block
- other benefits: it helps to avoid:
  - ↓ in retinal circulation
  - ↑ IOP
  - muscle toxicity from LA agents
- has small chance of allergy:
  - Immediate
  - Delayed
    - ~24hrs - responds well to steroids
    - difficult to distinguish from peri-orbital cellulitis

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Opthalmology - 13
**By Surgery**

- general rules:
  - Intra-ocular procedure = South facing or Flexi ETT
  - Extraocular procedure = Flexi LMA

**Cataract Extraction & Intraocular Lens**
= phaeoemulsification of opacified lens, removal and replacement with artificial intraocular implant

**Preoperative**
- check axial length <26mm for peribulbar block and INR
- patient must be able to lie flat
- day case issues

**Intraoperative**
- LA:
  - sub-tenons, peribulbar
  - may need dense block if
    - iris retractor needed
    - floppy iris syndrome - in BPH pts on α blockers
- LMA, ETT
- SV or IPPV
- supine
- O2 via nasal cannulae
- SpO2, BP, ETCO2
- sedation via midazolam, fentanyl, propofol

**Postoperative**
- simple analgesia

**Strabismus Surgery**
= extra-ocular surgery for correction of squint (may be bilateral)

**Preoperative**
- look for syndrome and metabolic disorders eg Downs, CP, congee heart disease, muscular dystrophy
  ➞ no link with MH
- children
- pre-analgesia paracetamol

**Intraoperative**
- supine
- LMA or RAE ETT
- SV or IPPV
- ↑ ed oculo-cardiac reflex (60%)-
  ➞ keep norm ETCO2
- if LA’s used -
  - should use short acting ie lignocaine
  - surgeon needs to fine tune sutures LA free
- avoid sux:
  - increases tone of muscles for 20min
  - makes surg Ax difficult
  - ↑ ed risk of MH
- anaesthetic affect on gaze:
Guedel's signs
- propofol may affect gaze the least & is titrateable → TIVA
- volatiles need to be adequate depth to ensure neutral gaze
- PONV cares - is highest risk of all operations ie 80% : at least double antiemetics (0.1mg/kg dex, 0.15mg/kg ondansetron)
- avoid opioids completely

Postoperative
- 1mg/kg propofol at end of procedure to ↓ chance emergence delirium
- simple analgesia
- topical LA
- PONV care

Vitreoretinal Surgery
= intra-ocular surgery -> vitrectomy, cryotherapy, laser, plombage, insertion of oil or gas, scleral banding
  ↓ done for retinal haemorrhage or detachment

Preoperative
- older
- co-morbidities (HT, IHD, DM)
- may be retinal detachment thus semi urgent

Intraoperative
- supine
- 85% sub-tenons ok otherwise GA with ETT
  retro/peri bulbar generally contraindicated
- intra-op alternates between very stimulating and not - long acting LA ideal to cover this
- ~1hr surgery
- Laser precautions
- propofol + remi ideal as is more painful op
- avoid nitrous - may place insoluble has bubble to hold retina in place ⇒ must also avoid flying
  and for 3/12 post op if having rpt surgery
- wait until surgeon completely finished before waking
- deep extubation

Postoperative
- minimal pain post
- PONV cares

Other Anterior Segment Procedures
- eg penetrating keratoplasty (cornea transplantation, glaucoma drainage, intracapsular cataract extraction)

Preoperative
- check glaucoma meds:
  - β blocker drops ⇒ bradycardia

Perioperative
Induction
- control of IOP crucial - sudden decompression of tense eye ⇒ iris/lens prolapse, choroidal haemorrhage:
  IPPV & EtCO2 control
  consider mannitol, acetazolamide
- oculocardiac reflex: IV atropine not contraindicated as only partially absorbed by eye

Maintenance
- sub Tenons v useful
- ↑↓ pain as vitreoretinal surgery
Dacrocystorhinostomy
= probing of tear duct, insertion of drainage tube, formation of stoma between tear duct and nasopharynx

Preoperative
- standard assessment
- can be done solely under LA with surgical experience

Intraoperative
- assoc with ↑risk of bacteraemia - if cardiac defects should receive prophylactic Abx
- supine, head up
- ETT RAE or LMA
- SV or IPPV
- blood passes into nasopharynx -> topical vasoconstrictors, throat pack
- moderate hypotension & slight head up
- suction and examine airway under direct vision prior to extubation

Postoperative
- simple analgesia
- topical LA @ end

Penetrating Eye Injury
= EUA, debridement and closure
- common and difficult in paeds

Preoperative
- risks = elevation of IOP with risks of extrusion of vitreous, haemorrhage and lens
- IV sedation to control situation if very distressed
- premedication with simple analgesia
- full stomach - if eye not salvageable then surgery is non-urgent & can wait

Intraoperative
- RSI with care to minimise effects of sux on ↑IOP (effect lasts 15mins):
  › large dose of induction agent + opioids to ↓IOP
  › RSI rocuronium & sugammadex
  › pre-curare with low dose roc then sux
  › co CVS agents:
    - IV lignocaine 1mg/kg
    - esmolol IV
  › modified RSI with remi instead of sux
- NB other effects on IOP:
  › ↑IOP:
    - cough/strain
    - external pressure on eye
    - constriction to venous drainage
    - Ketamine
  › ↓IOP:
    - Etomidate ↓IOP by 50%
    - any other anti-HTN agent eg thio, propofol

Postoperative
- simple analgesia