

Assessment of the Glaucoma Patient: IOP, Tonometry and Pachymetry

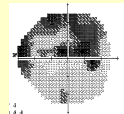
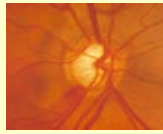
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Changing perspectives on IOP

- Glaucoma is characterised by raised IOP, optic neuropathy and RNFL damage causing visual field loss – *traditional view*
- '...progressive optic neuropathy, with a typically cupped, pale optic disc and a characteristic loss of sensitivity to light' – *Sponsel in 1980's*
- '...a variable combination of raised IOP, optic disc changes and visual field loss' – *Quigley in 1990's*
- RCT evidence on role of IOP – 2000+

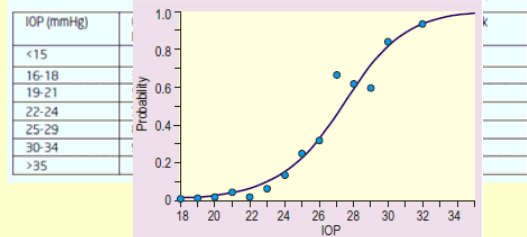
Risk factors for POAG

- Age
- IOP (1° modifiable factor)
- Race
- Family history
- High myopia
- Corneal thickness
- Diabetes Mellitus (controversial)
- Vascular factors
 - Cardiovascular disease
 - Vasospasm (migraine, Raynaud's)
 - Systemic hypotension



IOP as a risk factor

TABLE 1
Prevalence of POAG at different levels of screening IOP and the relative risk at specific levels of IOP, from the population-based Baltimore Eye Study (Sommer et al. 1991)⁹



IOP and clinical trials

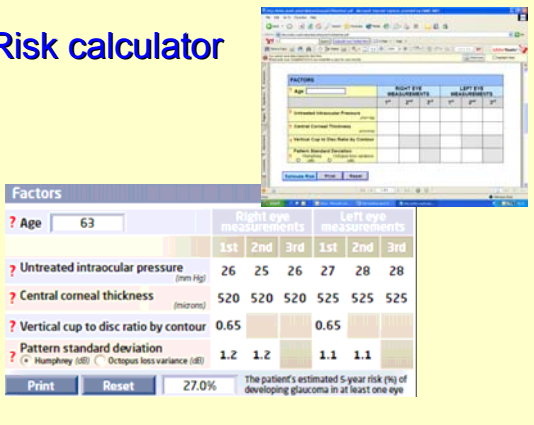
- Key randomised glaucoma trials
OHTS, EMGT, CNTGS, CIGTS, AGIS, EGPS
- Lowering IOP exerts a favourable influence on the development and progression of glaucoma
- Lower IOP means better protection
- Lowering IOP does not always stop progression
- Large inter-individual variation in IOP reduction/progression relationship

OHTS summary



- Multi-centre study
 - 1636 patients with OHT (24-32mmHg) 40-80 yrs, comparing conversion rate to glaucoma in patients randomised to Rx versus no Rx
- >90% of OHT pts did not convert after 5 years
- Conversion 4.4% in Rx group and ~9% in control group (i.e. no Rx)
- Predictors for conversion to POAG
 - Age, CD ratio, PSD, IOP and ↓ CCT

Risk calculator



EMGT study summary

- First treatment *versus* no treatment RCT in early glaucoma
- Population screening 44K
 - 255 pts recruited
- Randomised to IOP ↓ or no treatment
- Limited treatment
 - Laser (+ Betaxolol) ~25% IOP reduction
- Reduced progression risk by ~50%

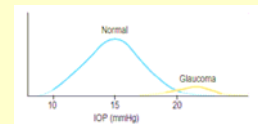
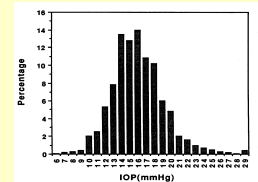
IOP in management

- Primary aim of treatment is to prevent the loss of functional vision within the patient's expected lifetime
- '...to maintain the patient's quality of life at a sustainable cost' (EGS 2003)
- **Primary method - lowering of IOP**
- Other options
 - Direct neuroprotection
 - Improve ocular blood flow

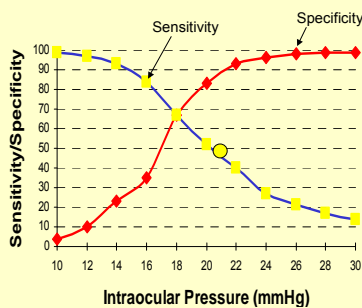


Distribution of IOP

- Av=15.7 mmHg
- SD=2.7 mmHg
- Range 10-22 mmHg
- Distribution skewed
- Diagnostic accuracy
 - Sensitivity/Specificity



IOP and Glaucoma Detection



Applanation tonometry

- Imbert-Fick law
- $IOP = \text{tonometer weight (g)} / \text{area (mm}^2\text{)}$
- Assumptions
- Method of choice for tonometry (currently)
- Constant area, variable force
- Robust, simple design



Goldmann tonometer

- Force required to appanate area of 3.06mm^2
 - Very little fluid displaced ($0.5\mu\text{l}$)
 - Corneal resistance = surface tension ($3\text{-}4\text{mm}\Theta$)
 - Tonometer force=IOP
 - Force (g) x 10=IOP (mmHg)
- Intra-observer variability is good
 - SD of differences $<1\text{mmHg}$
- Inter-observer variability is poorer
 - SD of differences is $\sim 1.6\text{mmHg}$



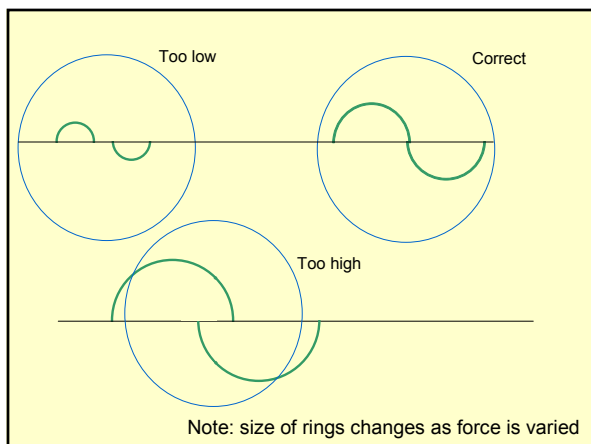
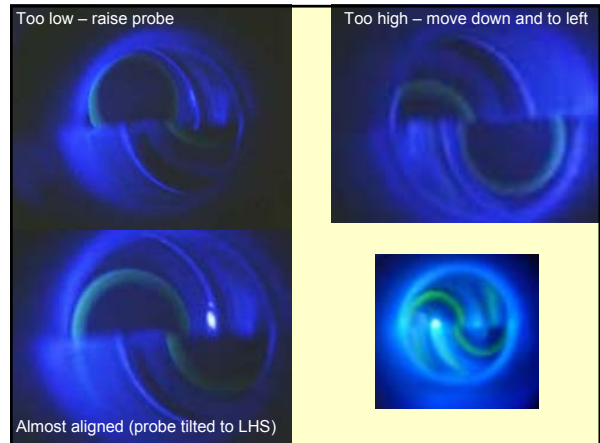
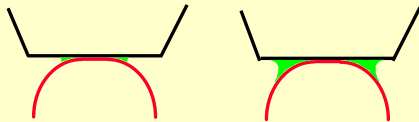
Errors

- Lids touching the probe (\uparrow IOP)
- Surface tension force altered (minimal)
- Prolonged contact (\downarrow IOP)
- Corneal* astigmatism ($>3\text{DC}$)
- Incorrect vertical alignment (\uparrow IOP)
- Calibration (systematic or random \uparrow or \downarrow)
- Observer errors (\uparrow or \downarrow IOP)
- Meniscus width (usually \uparrow IOP)



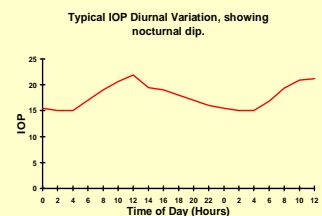
Meniscus width

- Thickness of fluorescein ring
- Ideal $\sim 1/10\text{th}$ diameter cone (0.3mm^*)
 - excessive (2mm) higher IOP estimates by $\sim 2\text{mmHg}$
 - narrow ($<0.1\text{mm}$) lower IOP estimates by $\sim 0.35\text{mmHg}$



Factors affecting IOP – short term

- Diurnal range
 - Normal $\sim 3\text{-}6\text{mmHg}$
 - Glaucoma average $\sim 13\text{mmHg}$
 - Plasma cortisol (?)
 - Higher in mornings (mid-late pm \downarrow , esp males)
 - Repeat tonometry and phasing (HES)



Factors affecting IOP – short term

- **Arterial pulse**
 - ‘ocular pulse’ – variation with heartbeat (3-4 mmHg)
- **Drinking/Fluid intake**
 - Water and coffee +3 mmHg in 20 min
 - alcohol -3mmHg in 5 min
- **Contraction of extra/intraocular muscle**
↑IOP
 - Gaze away from primary position
 - Accommodation
 - Blinking and lid squeezing



Factors affecting IOP – short term

- **Blood pressure, exertion, posture**
 - body position
 - sitting to supine 1-6 mmHg increase
 - inversion increases++ (to 30-35 mmHg)
 - aerobic exercise can lower IOP
 - straining can increase IOP
 - holding breath
 - resistive wind instrument
 - weightlifting
 - tight collar or neck tie (4mmHg)



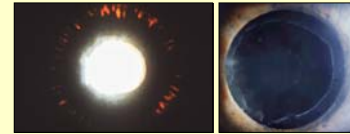
Factors affecting IOP – ‘longer term’

- Age - IOP ↑ with ↑ age
- Sex - IOP ↑ in older females
- Race - IOP ↑ in African/Asian
- Inheritance
- Myopia
- Corneal characteristics
- *Systemic disease*
- *Ocular disease*



Systemic and ocular disease

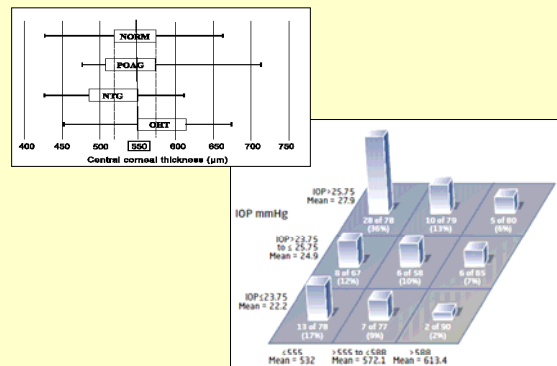
- Systemic disease
 - association between raised IOP/Glaucoma and systemic hypertension and DM
- Ocular disease
 - the secondary glaucomas
 - anterior uveitis and retinal detachments



Corneal characteristics

- Corneal thickness, curvature, elasticity and hydration properties will affect IOP
 - Thickness
 - IOP reading ↑ (i.e. higher than true IOP) if CCT ↑
 - IOP reading ↓ if CCT ↓
 - Curvature
 - IOP reading ↑ if steeper K's
 - IOP reading ↓ if flatter K's
 - Little clinical significance
 - Rigidity/elasticity (assessment more difficult)
 - Not dependent on CCT alone
 - Corneal hydration, composition of stroma

Corneal thickness and IOP



Corneal thickness

- Knowledge of CCT provides information on an individual's risk and allows 'correction' of IOP
 - OHTS, Brandt 2004
- No single correction factor is agreed upon
- Error range of 0.2-0.7mmHg per 10 micron difference from an average CCT is suggested
 - European Glaucoma Society (2003)

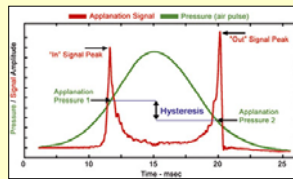


Tonometry: some developments

- Ocular Response Analyser
- Pascal Dynamic Contour Tonometry
- OBF
- Tonopen

ORA

- NCT principle - bi-directional applanation process
- Cornea moves inwards (past applanation into concavity) and then outwards passing through 2nd applanated state
- Difference in air force for inward and outward events (different pressure values)
 - 'Hysteresis': aggregate effect of corneal rigidity, thickness and hydration
 - IOPcc: 'corneal compensated IOP'



Pascal DCT

- Based on principle of contour matching - minimum corneal distortion
- Claims to eliminate the effects of CCT and rigidity associated with the GAT
- IOP values claimed to be closer to true manometric levels compared to GAT¹
- No difference in IOP readings taken before and after LASIK²
- Difficult on some patients
- Reasonably reproducible



¹Kniestedt et al, Archives of Ophthalmology 2004
²Kaufmann et al, IOVS 2003

OBF Ocular blood flow tonometer

- Overcomes some of the problems encountered in earlier Langham tonometer
- Helpful in vascular aetiology of POAG/NTG?
- Benefit of OBF now questioned
- Still affected by corneal thickness (more than GAT?)
- Measures
 - IOP (mmHg)
 - pulse amplitude (mmHg)
 - pulse volume (μl)
 - pulse rate (/min)
 - ocular blood flow (μl/min)

