Financial Disclosure

• Consultant to:
  – Abbott Medical Optics (AMO)
  – Alcon
Eye = The “Globe”

• Dimensions – average eye is about 23 mm in diameter
  – about the size of a quarter
• Antero-posterior diameter – or “axial length”
  – Varies between 20 – 30 mm or more
  – Each mm results in a refractive change of ~ 3 D
  – Hyperopic eyes shorter, myopic longer
  – A highly myopic eye would be about the size of a “toonie”
  – Laser and ultrasonic measurements allow this to be
    measured accurately within 0.05 – 0.1 mm, allowing good
    refractive accuracy post cataract surgery
Conjunctiva

- Clear mucous membrane covering the sclera and reflected back onto the inner eyelids
- Epithelial layer including mucous secreting goblet cells, and a vascular substantia propria containing lymphatics, plasma cells, macrophages, and mast cells
- “Tenon’s capsule” is a thin fibrous layer between the conjunctiva and the sclera
Conjunctiva

- Innervated by trigeminal nerve (V1)
- Bulbar conjunctiva on the globe, and palpebral conjunctiva on inside of lids, fornix the cul-de-sac where it reflects from the globe to the lids
- Impossible for a contact lens to “get behind the eye”, though the superior fornix is deep and it can get lost up in there!
- Upper lid requires “double-eversion” to see this area
Conjunctiva

1. Limbus
2. Bulbar Conjunctiva
3. Fornix
4. Palpebral Conjunctiva
5. Punctum
6. Lid margin
Lid Eversion
Conjunctiva

- Accessory lacrimal glands of Krause and Wolfring are in the stroma, and the mucous secreting goblet cells are in the epithelium
- This is why conjunctival alkali burns, or Stevens-Johnson syndrome cause severe dry eye when the conjunctiva is damaged
- The accessory lacrimal glands and goblet cells may function less well with aging, contributing to dry eye symptoms – including the paradox of the associated watery eye from “reflexive” tearing from the main lacrimal gland
Cornea

• Clear window allowing light to pass through, though composed of the same elements as sclera
• Regular spacing and orientation of collagen fibrils permit clarity; disruption by injury or edema causes the cornea to become opaque & white
• Convex, contributes about 2/3 of eye’s refractive power
• 0.5 mm centrally, 1 mm peripherally
Cornea

- Laser eye surgery creates a flap about 0.12 mm thick in the cornea, and then about 0.012 mm is removed per diopter of refractive correction.
Cornea

- Avascular and in a state of relative dehydration (endothelial pump)
- Receives nutrients from tears, atmospheric oxygen, aqueous humour & limbal capillaries
- 5 layers:
  - Epithelium – 35-50 microns
  - Bowman’s membrane – 10-12 microns
  - Stroma – 450 microns centrally, 900 peripheral
  - Descemet’s membrane – 3-12 microns
  - Endothelium – 4-6 microns
Corneal Layers

Graphic

Microscopy

1. Epithelium
2. Bowman’s membrane
3. Stroma
4. Descemet’s membrane
5. Endothelium
Corneal injuries

- Epithelium heals rapidly without scarring
- Innervated by CN V1 – epithelial injuries expose superficial nerve plexus which is very painful
- Bowman’s layer and stroma heal with scarring if damaged and do not regenerate
- Endothelium when damaged does not regenerate; adjacent cells enlarge and slide to cover the damaged area; if enough cells are damaged the cornea will swell from failure of the “pump” and an edematous cloudy cornea will result – “bullous keratopathy”
- The epithelium may not adhere well to the swollen cornea, and slough off – causing pain
Failure of Endothelial “Pump”

Endothelial Cells

Bullous Keratopathy
Posterior Radial Keratotomy

WW2 Japanese pilots, initial success, also led to the discovery of the importance of the corneal endothelium!
Cornea

• Diameter ~ 12 mm
• Most contact lenses are 14 mm in diameter, to allow an overlap of 1 mm around the cornea
• Cornea blends into the sclera at a junction called the “limbus”
• The limbus has stem cells than can regenerate the corneal epithelium – damage to the limbus will prevent re-epithelization after injury
Aqueous Humour

- Fills the anterior & posterior chambers lying between the cornea and the ciliary body
- Provides nutrients to the cornea and lens, and removal of waste
- Produced by the ciliary body epithelium at a rate of about 2 ul/min
Anterior Chamber

- Anterior chamber is about 3 mm deep centrally, and has a volume of 200 ul
- The aqueous humour turns over about every 1.5 – 2 hours
- Drains via the trabecular meshwork into the canal of Schlemm, then into the episcleral veins
- The intraocular pressure results from the balance between inflow and outflow of the aqueous humour
Uveal Tract:
Iris, Ciliary Body & Choroid
u·ve·a
ˈyoʊvəə/
noun
(Latin uva – “grape”)

The pigmented layer of the eye, lying beneath the sclera and cornea, and comprising the iris, choroid, and ciliary body.

The name is possibly a reference to its reddish-blue or almost black colour, wrinkled appearance and grape-like size and shape when stripped intact from a cadaveric eye.
Uveal Tract: Iris

- Iris arises from the ciliary body and separates the anterior and posterior chambers
- Visible coloured portion of the eye
- Pupil is central aperture; constricts via the sphincter muscle (parasympathetic) and dilates via the radial muscle (sympathetic)
- “Flight or fright” response = sympathetic = pupil dilation!
- Pupil regulates the amount of light to provide the correct contrast for the retinal image
**Uveal Tract: Ciliary Body**

- Triangular body, extending from the scleral spur to the ora serrata (edge of the retina)
- Pars plicata is the more anterior portion, consisting of ridged ciliary processes which produce aqueous humour
- The zonules of Zinn arise from valleys between the ciliary processes and support the lens
- Pars plana is more posterior, quite avascular, extends 4 mm from the pars plicata to the ora, and lies about 3-4 mm posterior to the limbus
- Pars plana provides the safest surgical option to the retina and vitreous (PPV = pars plana vitrectomy)
ORA SERRATA

Iris
Pars plicata
Pars plana

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INJECTIONS VIA THE “PARS PLANA”
Ciliary Body: Muscles

Longitudinal muscles in the ciliary body can contract, pulling against the scleral spur and opening the trabecular meshwork and increasing aqueous outflow.

- Cholinergics (i.e., pilocarpine) work by this mechanism.
Ciliary Body: Muscles

Circular muscle fibres in the ciliary body can constrict, narrowing the diameter of the body allowing the zonules to relax – this allows the lens to become more convex and "accommodate" moving the eye’s focal point to near.
Accommodation

(Animation Courtesy of Daniel B. Goldberg, MD)
Uveal Tract: Choroid

Continuous with the iris and ciliary body, and extending posteriorly under the retina (beneath the retinal pigment epithelium)
Vascular plexus supplying the outer retina, and dissipating heat from retinal metabolic processes
About 0.22 mm thick centrally, 0.1 mm peripherally
• Transparent, biconvex refractive body enclosed in a capsule
• Lens cells are primarily water and clear lens proteins called crystallins
• Accounts for about 1/3 of the refractive power of the eye
• 9-10 mm in diameter, and thickens during life from 3 mm at birth to about 6 mm at age 80 (continual addition of new lens fibres)
• Contraction of the ciliary body muscle relaxes the zonules supporting the lens, causing the elastic lens to assume a more spherical globular shape and increasing its refractive power (accommodation)
With modern cataract surgery, the lens is removed by ultrasound through a small opening in the anterior portion of its capsule – the intraocular lens (IOL) is implanted within the capsular “bag”
MODERN CATARACT SURGERY
Vitreous Humour

• Clear, gel-like fluid composed of 99% water and 1% collagen and hyaluronic acid

• Volume is about 4 mL, and it fills about 4/5 of the eye; gives shape to the globe

• Attached at the vitreous base (2 mm anterior and 4 mm posterior to the ora serrata), as well as some attachments to the optic disc, retinal vessels, and perimacular region
Vitreous Humour

- Liquifies with age, and may separate from the inner retina – “posterior vitreous detachment” = PVD
- This can lead to retinal tears in a small % of patients, and the fluid can then leak through the tears under the retina – causing “rhegmatogenous” retinal detachment
- Many patients with PVD will see a prominent “floater” called a “Weiss ring” caused by thickened vitreous that used to be attached to the optic disc
PVD & RD

Diagram showing:
- Area of detachment
- Vitreous
- Tear in retina
- Area of detachment
- Retina
Retina

• Thin, transparent neural layer 0.15 – 0.3 mm thick
• The orange-ish colour of the fundus comes from the underlying retinal pigment epithelium (RPE) and choroid – not from the retina
• The “inner” retina refers to the retina abutting the vitreous; the central retinal artery and its branches (visible on fundoscopy) supply the inner retina
• The “outer” retina is next to the choroid, from which it receives its nutrient supply
Retina – ten layers

- Internal limiting membrane
- Nerve fibre layer
- Ganglion cell layer
- Inner plexiform layer
- Inner nuclear layer
- Outer plexiform layer
- Outer nuclear layer
- External limiting membrane
- Rods and cones
- Retinal pigment epithelium

Direction of incident light.
Retina

• The retina is a neural layer that is an extension of the optic nerve
• Light has to travel through the inner layers of the retina to reach the photoreceptors
• The “inner” nerve fibre layer becomes whitish/opaque when swollen (ie with small infarcts – “cotton wool spots”, blunt eye trauma “commotio retinae”, or papilledema)
Cotton Wool Spots

Commotio Retinae

Papilledema
Retina

- Two types of photoreceptors: rods and cones
- Cones: about 6 million, greatest density in macular area, responsible for colour vision
- Centre of the macula is the fovea, and its centre – the foveola – consists entirely of close packed cones – resulting in high visual acuity in this area
- Macular degeneration damages this area, resulting in severe visual acuity loss
Retina

- Rods: 120 million rods, greater peripherally, none at foveal centre, function best in dim light
- Require about 30 minutes to become dark-adapted for peak function in the dark
- Contain rhodopsin, which is broken down by light and must be continually synthesized – which requires vitamin A
Retinal Pigment Epithelium

- Pigmented hexagonal monolayer of cells
- Multiple functions including:
  - Vitamin A metabolism
  - Phagocytosis of rod and cone outer segments
  - Absorption of light (reduction of scatter)
  - Heat exchange
  - Maintenance of outer blood-retina barrier
  - Formation of basal lamina (part of Bruch’s membrane)
Retinal Pigment Epithelium

- Incomplete “digestion” of rod and cone outer segments results in yellow deposits under the RPE called drusen.
- Drusen may indicate a decline in cellular function of the RPE.
- “Dry” age-related macular degeneration (ARMD) tends to occur in areas with drusen.
Bruch’s membrane

- Series of connective tissue sheets between the RPE and the inner choroid (choriocapillaris) which includes the basal lamina of both structures
- Defects in this membrane can allow choroidal vasculature to get under the retina (“wet” macular degeneration) where the vessels eventually fibrose leading to “disciform scarring” and severe visual loss if it occurs in the macular area
“Dry” vs “Wet” ARMD

Cross section of Macula with Dry AMD

Cross section of Macula with Wet AMD

Drusen thinning Retina

Abnormal Blood Vessels breaking through Bruch’s Membrane
Sclera

- Outermost layer of the globe
- Tough, fibrous opaque layer, covers 5/6 of eye, structurally similar to cornea but collagen fibres arranged haphazardly
- 1 mm thick, except at EOM insertions only 0.3 mm thick
- Ruptures from trauma – occur at EOM insertions, limbus or optic nerve insertion
Extraocular Muscles

- Six muscles – four recti (straight) and two oblique (angled)
- Rectus muscles originate at the Annulus of Zinn at the apex of the orbit, and all are about 40 mm long and 10 mm wide
  - Superior Rectus: Elevate, Intort, Adduct
  - Inferior Rectus: Depress, Extort, Adduct
  - Medial Rectus: Adduct
  - Lateral Rectus: Abduct
Extraocular Muscles

• Oblique muscles:
  – Superior oblique: Depress, Intort, Abduct
  – Inferior oblique: Elevate, Extort, Abduct
• All CN III, except lateral rectus (VI) & superior oblique (IV) – LR6, SO4
• Superiors INTORT – “SIN” not “SEX”
• Superior oblique (IV) palsy – vertical diplopia – hypertropia (elevation) of affected eye
Extraocular Muscles

1. Levator Palpebrae Superioris
2. Superior Rectus
3. Superior Oblique
4. Medial Rectus
5. Lateral Rectus
6. Inferior Oblique
7. Inferior Rectus
8. Superior Orbital Fissure
9. "
10. Optic canal
Optic Nerve

- About 1.2 million axons
- Axons originate in the ganglion cell layer of the retina and synapse in the lateral geniculate body
- Visible optic disc on fundoscopy is only 1.5 mm in size; no photoreceptors on the disc – therefore it creates the physiologic blind spot
- 25-30 mm from the eye to the optic foramen
“Cupping” of Optic Disc

- Normal
- Large Disc – “Physiologic” large cup
- Normal size disc – pathologic large cup
Optic Nerve Edema

GCA – Global Ischemia & Thrombosis

NAION – watershed infarct

Papilledema – external compression of ON
Optic Pathways

- Optic nerve
- Optic chiasm
- Optic tract
- Lateral geniculate nucleus
- Optic radiation
- Striate cortex

Left monocular visual field

Right monocular visual field
Eyelids

- Upper eyelid raised by levator palpebrae (CN III)
- Closure by orbicularis oculi (CN VII)
- Both upper and lower lids usually cover a small part of the cornea
- Blink rate – 10-30 times per minute, average about 15; decreases to as low as 4-7 times per minute with computer tasks – contributing to dry eye symptoms
Eyelid Structure

- Müller's muscle
- Tendon of levator palpebrae superioris muscle
- Conjunctival cul-de-sac (fornix)
- Bulbar conjunctiva
- Orbital septum
- Orbicularis oculi muscle
- Superior tarsus
- Zeis (sebaceous) gland
- Cilia
- Palpebral conjunctiva
- Meibomian glands

Gray Line
EYE EXAMINATION IN THE PRIMARY CARE OFFICE
Order of Examination

- Visual Acuity
- Visual Fields
- Pupils
- Motility
- External Exam
- Tonometry
- Ophthalmoscopy
Visual Acuity

- Always ask patient to wear glasses appropriate to the testing distance (VA<sub>acc</sub> OD OS)
- Must test each eye separately
- Children < 2-3 yrs – document ability to fix & follow with each eye
- If VA < 20/400, document best of CF=“counting fingers”, HM=“hand motions”, LP=“light perception” or NLP=“no light perception”
Pinhole

- A pinhole occluder will correct refractive errors up to 3-4 diopters
- It is especially useful on top of glasses, if the glasses are “out of date”
- Vision only improves if the cause is “refractive” in nature – not with organic pathology
Near Visual Acuity

- Useful with inpatients or if no distance chart available in office/clinic
- Older patients will require reading glasses unless myopic (“nearsighted”)
- Can improvise with magazine, newspaper
Large Headlines 20/200 – 20/800
Why Does Her Belly Hurt?

Complications from surgery provide an important lesson for ER doctors

“OWW! OH. GOD. OH. PLEASE.”

Everyone in the emergency room froze. Following the screams, I hurried to a far cubicle.

“Oh, my God,” a woman shrieked, clutching her belly. She looked about 40, was noticeably overweight, and was wearing a business suit.

“You OK?” I whispered to the attending physician.

She nodded and said: “She had a gastric bypass two years ago. Sudden onset of severe epigastric pain. Her chest X-ray shows no free air. We’re on our way to a CT scan.”

Air in the abdomen equals stomach or intestinal perforation, but it doesn’t always show up on an X-ray. Although perforation is rare in healthy young women, her bypass for weight loss put her in another category. I tried to think up a list of likely complications, but I couldn’t come up with more than a few.

“You’ll be OK,” I said and grabbed the stretcher railing.

“Ow. Oh, Jesus,” she said, gasping as we headed down the hall. “I can’t believe this.”

The attending physician turned to a nurse: “Six of morphine, please.”

A half hour later we had a diagnosis.

“The scan shows free air. Her surgeon wants her uptown,” the attending physician said. “He did the bypass.”

One out of 20 American adults is severely obese, 5 of those 20 are obese, and control obesity in the vast majority of cases, an increasing number of people are turning to bariatric surgery. In 1998 American doctors performed 13,365
Myopia & Hyperopia
MYOPIA
• Retinal detachment
• Open angle glaucoma
• Macular degeneration

HYPEROPIA
• Angle closure glaucoma
Visual Fields

- Many acceptable techniques
- Most common is monocular finger counting in four quadrants
- Will only pick up very gross abnormalities
- Some patients will attribute right or left visual field loss to the eye on the affected side
Pupils

- Size (mm) in dim light, reactivity to light (1-4+)
- Anisocoria = different sized pupils
- "Swinging-flashlight test"
Anisocoria

**LARGER**
- CN 3 palsy
- Adie’s pupil
- Trauma/surgery
- Dilating drops

**SMALLER**
- Horner’s syndrome
- Iritis
  - Miotic drops (pilocarpine)
  - Long-standing Adie’s
  - Argyll-Robertson pupil(s)

* 10-15% of patients have a small (< 1 mm) difference at times (physiologic anisocoria) but both pupils react normally
Relative Afferent Pupillary Defect

• Indicates optic nerve disease or global retinal disease
• Optic neuritis, ischemic optic neuropathy, advanced asymmetrical glaucoma, optic atrophy
• Central retinal artery or vein occlusion, retinal detachment
• NO RAPD seen in “media” problems, such as cataracts, corneal scarring, or vitreous hemorrhage
Motility

- Can test bilaterally up/down, right/left
- Little to no sclera seen when eye fully abducts/adducts
- \( \frac{1}{3} \) iris covered by upper lid with upgaze,
- \( \frac{1}{2} \) by lower lid in downgaze
- If abnormal, must then test each eye separately
Corneal Light Reflexes
(Hirschberg)

Abnormal Eye (note pupil reflex)

Normal Eye

CN 3 palsy
Down and out

CN 4 palsy
Displaced up

CN 6 palsy
Turned in
External Exam

• Just get up close with a light (transilluminator or ophthalmoscope) and look
• Lids/lashes, conjunctiva/sclera, cornea, anterior chamber, iris/pupil, lens
Cortical Cataract

Blepharitis

Marginal Infiltrates

Nuclear and Posterior Cataract
Tonometry

Tono-Pen® XL

Operation-at-a-Glance

Operation Set Up (Refer to Figure 1 Above)
The proper set-up of the Ocu-Film® Tip Cover is essential for the precision and accuracy of the tonometry measurement.
The application procedure below should be followed. A new Ocu-Film Tip Cover must be used for each new patient.

Position the Ocu-Film applicator on the transducer ridge. Roll the Ocu-Film tip cover onto the Tono-Pen tip and remove applicator. Be certain that film is flat across the tip, but not taut.

Verify that Ocu-Film tip is rippled, but without a crease across the transducer surface. Refer to above pictures.

Caution: OCU-FILM® TIP COVERS CONTAIN NATURAL RUBBER LATEX, WHICH MAY CAUSE ALLERGIC REACTIONS.

Visit our website at www.medtronicophthalmics.com
Red Reflex Test
(Bruckner)

- A good red reflex requires clear ocular media, no large refractive error, and normal eye alignment
- This is best performed a couple of feet away, shining the direct opthalmoscope light (set to zero diopters and largest aperture) at both eyes
- Patient is asked to look AT the light
Normal Red Reflexes
Strabismus
Cataracts
Red Reflexes

• Are an excellent way to screen infants & children for asymmetrical refractive errors & strabismus
• They should be a part of your general assessments and well baby checks
Fundoscopy

• Optic disc & macula can usually be seen through undilated pupil
• (If you would like to dilate, try to check for shallow angles first)
• Approach just slightly temporal to straight on (15°)
• Diopter dial is just to correct refractive error (yours & patient’s) – start at zero
• Ask patient to look at light when you want to see the macula
Shallow Anterior Chamber
Macula

Fovea
Summary

• Visual Acuity – with glasses!
• (Visual Fields) – if visual complaints, and normal VA!
• Pupils – “swinging flashlight”
• Motility – together, then separately
• External Exam – get in close
• Ophthalmoscopy – simultaneous bilateral red reflexes!