Instrumental Eye Examination

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“BEDSIDE” EXAMINATIONS

**OPTICAL MICROSCOPY (FUNDUSCOPY)**

**DIRECT OPTICAL MICROSCOPY**

**INDIRECT OPTICAL MICROSCOPY**

**OPTICAL MICROSCOPY FINDINGS**

1. Hypertensive retinopathy
2. Diabetic retinopathy
3. Pedestal aspects

**APPLICATION TONOSOMETRY**

**SLIT LAMP EXAMINATION (BIOMICROSCOPY)**

**ULTRASONOGRAPHY**

**NEUROGRAPHY**

**Electrooculography (EOG)**

**Video-oculography**

**VISUAL Evoked POTENTIALS (VEP)**

**Electroretinogram (ERG)**

**INTRAVENOUS FLUORESCENCE ANGIOGRAPHY (IVFA)**

**Pharmacological pupil dilation** → see p. Eye61

**Pharmacological cycloplegia** → see p. Eye61

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**“BEDSIDE” EXAMINATIONS**

Examination details → see p. D3eye

1. **visual acuity** (incl. near vision acuity) - Snellen chart.
2. **visual field** - confrontation testing, perimetry. Amisol grid.
3. **color vision**
4. **contrast sensitivity**

**CONE**:

1. **eyeball position** – MRD.
2. **pupil** – reactions to light, accommodation.
3. **eyeball movements and position in orbit** – tests for nystagmus, heterotropia / heterophoria (diplopia), prosopias.
4. **Suprachoroidal space** - tests for saccades, smooth pursuit. see p. Eye64

**Higher visual coats** – tests for unilateral visual neglect, agnosias.

**OPTICAL MICROSCOPY (FUNDUSCOPY)**

- inspection of ocular fundus.
- ocular fundus – only place in body where arterioles are visible – diagnosis of vascular diseases (e.g. diabetes mellitus, hypertension).
- no pupillary dilation is required for optic disc visualization.
- use mydriatic (e.g. TROPICAMIDE) to visualize lens, vitreous and retina.

**DIRECT OPTICAL MICROSCOPY**

- provides very high magnification of fundus details.
- **DIRECT OPTICAL MICROSCOPY** - held relatively close to subject's eye; observer views upright magnified image.
- darken room as much as possible!!!
- remove patient's (and your own) glasses.
- start with large round beam of white light;
  - some use large round beam for large pupils, small round beam for small pupils.
  - slit-like beam is sometimes used to assess elevations & concavities in retina
  - red-free (i.e. green) light may show nerve fiber layer defects, small red lesions.
- start with lens disc at 0 dioptries; keep index finger on lens disc so that you can refocus ophthalmoscope during examination:
  - "adjust dioptres (looking at your own palm) before actual examination
  - rule "right-right-right" and "left-left-left"
  - use your right hand & right eye for PATIENT’S RIGHT EYE; your left hand & left eye for PATIENT’S LEFT EYE.
- place thumb of opposite hand on patient’s eyebrow – will give you proprioceptive guidance as you move closer to patient so you may gently elevate patient’s upper lid (that it will not obstruct view)
- ask patient to look straight ahead (or slightly toward examined side) and fix gaze on specific point on the wall.
- from position 30 cm away from patient and 15° lateral to his line of vision, shine light beam on pupil – note orange glow (red reflex).
- Red reflex absence (brunescens) suggests cataract or other intraocular opacities.
- keep both eyes open and relaxed (as if gazing in distance).
- keeping light beam focused on red reflex, move in toward pupil until opthalmoscope is very close to it (your forehead should be on or very near your thumb).
- if you have approached horizontally on 15° angle, you should now see **optic disc**; if you do not see disc, follow blood vessels centrally (guided by vessel branching angles) until you do:
**INSTRUMENTAL EYE EXAMINATION**

- **Eye 60 (2)**

**UK**

- Bring optic disc into sharp focus (by adjusting lens disc):
  
  a) If patient's eye (as well as your own) is normal, you can clearly focus on retina with **null diopters lens** (i.e. clear glass) – patient's natural lens and cornea focus exactly on retina!!!

  b) If patient is **myopic** (retinal structures look magnified more than usual; disc even may exceed size of your view) - use **minus diopters lens** (indicated by red numbers).

  - Normally retina is magnified ≈ 15 times, iris only ≈ 4 times.

  - Strength of lens required to bring retina into focus gives approximate measure of refractive error.

  c) If patient is **hyperopic** / aphakic (retinal structures look smaller but you can see much larger expanse) - use **plus diopters lens** (indicated by black numbers).

- Examine retina in four oblique directions – move your head and instrument as unit, using patient's pupil as imaginary fulcrum: alternative – ask patient to look superiorly (examine horizontally), temporally (examine vertically), inferiorly (examine horizontally), nasally (examine vertically).

- Finally, inspect macula – by asking patient to look directly into light.

  N.B. unless you use mydriatic, macula visualization is difficult (due to maximal miosis and due to corneal light reflex) – try moving slightly side to side.

- If you want to inspect anterior eyeball structures (e.g. lens opacities) – use **plus diopters lenses** (e.g. +10 D).

**INDIRECT OPHTHALMOSCOPY**

- Uses 20 diopters lens (stereoscopic view, very bright light source, pupil dilation) - more complete visualization of posterior pole and peripheral retina.

- **INDIRECT OPHTHALMOSCOPE** - held at arm's length from subject's eye; observer views inverted image through convex lens located between instrument and subject's eye.

**OPHTHALMOSCOPIC FINDINGS**

- Optic Disc – appears pink (capillaries accompanying axons) with sharp margins (except perhaps nasally):
**INSTRUMENTAL EYE EXAMINATION**

- Rings & crescents are often seen around disc edges:
  a) Scleral rings – white
  b) Choroidal crescents – black pigmented

- Rare finding is myelinated nerve fibers - irregular white patches with feathered margins (differentiate from exudates), obscuring disc edge and retinal vessels.

**RINGS AND CRESCENTS**

- **Physiologic Cup** (small depression in optic disc center)
  - Appears white (only large vessels perforate cup, but no nerve fibers).
  - Cup diameter is \( \frac{1}{3} \) horizontal disc diameter.
  - Although sometimes absent, cup is usually visible centrally or toward temporal disc side; grayish spots are often seen at its base.

**MIDULATED NERVE FIBERS**

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**MACULA** – avascular area, somewhat larger than disc, without distinct borders; tiny bright reflection at center is Fovea

Identify Arterioles & Veins:

<table>
<thead>
<tr>
<th>Arterioles</th>
<th>Veins</th>
</tr>
</thead>
<tbody>
<tr>
<td>Color</td>
<td>Light reflection</td>
</tr>
<tr>
<td>Color (A/V Width)</td>
<td>Bright</td>
</tr>
<tr>
<td>Light reflection</td>
<td>(A/V Width)</td>
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**NORMAL RETINAL ARTERIOLE AND ARTERIOVENOUS (A/V) CROSSING**

- Observe venous pulsations (as they cross disc); gentle eye pressure (through lid) makes such pulsations even more evident; venous pulsations disappear in ICP↑.
- Venous sheathing is seen most readily with direct ophthalmoscope.

**ARTERIOVENOUS CROSSINGS**

- Thickening of the arteriolar walls is often associated with visible changes in the arteriovenous crossings. Decreased transparency of the retina also probably contributes to the first two of the following changes.

**NORMAL FUNDUS OF A FAIR-SKINNED PERSON**

The fovea is not visible in this subject. Look for any lesions in the retina. Note the stippled or tessellated, or diamond-shaped, or the fovea, especially in the lower floor. This comes from normal choroidal vessels, undamaged by pigment.
PATHOLOGIC FINDINGS

Lesion description – use term “disc diameters” (normal optic disc is ≈ 1.5 mm diameter):
- e.g. lesion about 2/3 of disc diameter in size located at 1 o’clock, almost 2 disc diameters from disc:

**Red spots** in retina:

1. **Flame-shaped hemorrhages** are small, linear hemorrhages, often found in severe hypertension but not specific to this condition.

2. **Deep hemorrhages** are small, slightly irregular red spots often seen in diabetes. They may also be present in a number of other conditions.

**Retinal hemorrhages:**
- a) Flame-shaped - in superficial nerve fiber layer (e.g. hypertension, venous occlusion), originate from capillaries.
- b) Round (dot and blot) - in deeper layers (e.g. diabetes mellitus, septic infarctions), originate from capillaries.

N.B. **Retinal hemorrhages are always significant** - reflect vascular disease that usually is systemic (most commonly hypertension & diabetes)!

“Cotton wool” patches, s. soft exudates (hypertension, diabetes, retinal vein occlusion, etc. –) – **retinal microinfarctions** (ganglion cells + nerve fiber layer):
- border: ill-defined, fuzzy
- shape: ovoid, polygonal, irregular
- size: relatively large, but smaller than disc
- color: white / gray
- distribution: no definite pattern.

**Hard exudates** (hypertension, diabetes, etc.) – **extravasation of plasma lipoproteins**:
- border: well defined
- shape: may be small and round or may coalesce into larger irregular spots
- size: small
- color: creamy yellow, often bright
- distribution: often in clusters, circular / linear patterns, or stars.

*N.B. retinal hemorrhages are always significant - reflect vascular disease that usually is systemic (most commonly hypertension & diabetes)*
Drusen (normal aging):
- **border**: defined fairly well
- **shape**: round
- **size**: tiny
- **color**: yellowish white
- **distribution**: haphazardly and generally distributed, may concentrate at posterior pole.

Healed chorioretinitis:
- **border**: well defined, often outlined in pigment
- **shape**: irregular
- **size**: variable (small ÷ very large)
- **color**: white / gray with clumps of black pigment
- **distribution**: variable.

Senile macular degeneration:
- **Disc atrophy**: (death of optic nerve fibers leads to loss of tiny disc vessels – white disk):

- **Papilledema** (engorged, pink, hyperemic disk with blurred margins, vessels curve over disk borders; physiologic cup not visible):

- **Glaucomatous cupping** (increased pressure leads to increased cupping):
A hypertensive retinopathy
Keith, Wagener, Barker classification:

- **group 1** - constriction of retinal arterioles;
- **group 2** - constriction and sclerosis of retinal arterioles; a-v crossing anomalies (nicking, tapering, buckling);
- **group 3** - hemorrhages and exudates in addition to vascular changes;
- **group 4** (malignant hypertension) - papilledema.

**THE RETINAL ARTERIOLES IN HYPERTENSION**

**GROUP FIRMING**

- In hypertension the arterioles may show areas of firm, immobile segments with narrowing of the caliber of blood. The light reflex is also diminished. By the 3rd or 5th year the arteriolar wall thickens and becomes less transparent.

**GROUP MUCULAR STAR**

- Punctate exudates are easily visible here. Some are scattered, while others radiate from the fovea to form a macular star. Near the two small, soft exudates one disc diameter above the disc. The vessels opening at the top of the fovea and then run above the disc. The nasal border of the optic disc is blurred. The light reflects from the retina and the nasal side above and below the disc are increased. Note that in blood is visible within it. This is an example of a solid 32 arteriolar narrowing and arteriovenous nicking.
INSTRUMENTAL EYE EXAMINATION

Grade 1: early minor changes (seen at 1 o’clock) - increased tortuosity of retinal vessel, increased reflectiveness (silver wiring) of retinal artery.

Grade 2: increased tortuosity and silver wiring (upper arrow) with ‘nipping’ of venules at A-V crossings (lower arrow).

Grade 3: as in grade 2 + flame-shaped retinal hemorrhages and soft ‘cotton-wool’ exudates.

Grade 4: papilledema, retinal edema, and hard exudates around fovea, producing ‘macular star’.

DIABETIC RETINOPATHY

Punctate exudates have coalesced into homogeneous, waxy-looking patches that are typical of diabetic retinopathy. What kinds of red spots can you find? Microaneurysms are most easily visible about one disc diameter below the disc. A few deep hemorrhages can also be seen, around 2 o’clock and 5 o’clock about three disc diameters from the disc.

Moderate nonproliferative DIABETIC RETINOPATHY with microaneurysms and cotton-wool spots.

Fluorescein angiography of DIABETIC RETINOPATHY (intraretinal microvascular abnormality).

Proliferative DIABETIC RETINOPATHY with neovascularization and scattered microaneurysms.

Proliferative DIABETIC RETINOPATHY with neovascularization of optic disc.
Nonproliferative DIABETIC RETINOPATHY with clinically significant macular edema:

Vitreous and preretinal hemorrhage due to proliferative DIABETIC RETINOPATHY:

Fluorescein angiogram - numerous, small, dot-like capillary microaneurysms:

Clinically significant macular edema:

- Hard exudates within 300 µm of the center of the fovea if associated with adjacent areas of retinal thickening.
- Retinal edema >1 disc area in size and within 1 disc diameter of the center of the fovea.

High-risk characteristics for DIABETIC RETINOPATHY:

- Neovascularization within 1 disc diameter of the optic disc (NEVD) >1.5 disc areas in size or larger.
- Any NVB associated with preretal or vitreous hemorrhage.
PEDIATRIC ASPECTS

- ophthalmoscopy must be performed in all infants at age 2-6 months.
  - baby may be supine or upright in parent’s lap, also see p. D1eye
  - presence of red reflex excludes congenital cataracts, retinoblastoma and other opacities.
  - fundus is seen at “0” diopters, lens – at +15 diopters, cornea – at +20 diopters.
- newborns:
  - optic disc is paler, gray-white color (may lead to improper diagnosis of optic atrophy!); vs. salmon-pink color in older child.
  - peripheral vessels not well developed, foveal light reflex absent.
  - papilledema does not develop up to age 3 years (because open sutures & fontanelles accommodate ICP↑).
  - small retinal hemorrhages occur in 30-40% full-term newborns (esp. after vaginal delivery) - disappear spontaneously by 1-2 wk of age; extensive hemorrhages (accompanied by dilated, congested, tortuous retinal veins) suggest INTRACRANIAL BLEEDING.

APPLANATION TONOMETRY

- measurement of intraocular pressure (screen for GLAUCOMA).
  - applanation tonometer - instrument for application of small flat disk to cornea (applanation - flattening of cornea by pressure); noncontact tonometers also exist.
  - eye should be anesthetized (e.g. PROPARACAINE 0.5%).
A. SCHIØTZ tonometer - easy to use, portable, but requires thorough cleaning between uses; eye must be vertical with eyelids spread off globe.
B. GOLDMANN tonometry (used with slit lamp) - flattens only 3 mm² of cornea, requires more training, but is preferred method!

SLIT LAMP EXAMINATION (BIOMICROSCOPY)

- uses horizontally mounted microscope and special light source.
  - directly visualizes (stereoscopic view, very bright light source, pupil dilation): cornea, anterior chamber, iris, vitreous, posterior fundus pole (disc and macula).
  - especially useful for corneal pathology!

ULTRASONOGRAPHY

B-mode ultrasonography - for retinal tumors & detachments, vitreous hemorrhages, locating metallic and nonmetallic foreign bodies.
  - handheld B-scanner is available for studies in ophthalmologist’s office.
A-mode ultrasonography - to determine axial length of eye (needed to calculate power of intraocular lens before it is implanted).

NYSTAGMOGRAPHY

- accurately records eye movements and nystagmus.

ELECTRONYSTAGMOGRAPHY (ENG)

- disk electrodes are placed over nose bridge and lateral to each outer canthus.
  - because cornea is electropositive and retina is electronegative, electrodes will accurately record lateral eye movements.
VISUAL EVOLED POTENTIALS (VEP)
- cortical activity (best recorded over midoccipital region with reference to either midfrontal region or linked ears) in response to monocular visual stimuli: a) flashes of light b) checkerboard pattern (pattern reverses at 1 Hz so that white squares become black, and vice versa, without change in total luminance) - higher yield of abnormalities than flash stimuli, but requires more patient cooperation! c) light-emitting diode (LED) array stimuli.
- responses to ≈ 100 stimuli are generally averaged.
- typical VEP elicited by pattern-reversal stimulus is negative-positive-negative complex; positivity is most conspicuous and consistent and has latency to its peak of ≈ 100 msec (therefore called P100 response).
- VEPs are useful in evaluating anterior visual pathways; N.B. VEPs are not useful in evaluating lesions posterior to optic chiasm! (e.g. in cortical blindness, VEP may be normal!!!); retrochiasmatic lesions can be evaluated using MONOCULAR HEMIFIELD STIMULATION.

In analyzing VEP, latency of P100 response is measured:
1) interocular difference
2) comparison with normal values obtained using identical* technique
*physical attributes of stimulus normally influence latency!!!

Absence of P100 is abnormal!!!
- normal result is particularly helpful in excluding organic lesions (when functional visual loss is suspected).
- VEPs can be used to evaluate visual fields, but approach is time consuming, requires close patient cooperation, and is less sensitive than standard perimetry.
- pattern-elicited VEP can be used to measure refractive error / detect amblyopia in preverbal children-unable to cooperate for behavioral testing.
- can suggest lesion of anterior visual pathway; examples: a) optic neuritis: P100 absence → prolonged P100 latency (persists indefinitely) + normal shape.
b) compressive lesions of optic nerve: markedly abnormal VEPs shape + delayed latency
c) ischemic / toxic optic neuropathies: markedly attenuated P100 amplitude + normal latency.

ELECTRORETINOGRAM (ERG)
- recording potential fluctuations between electrode on cornea and another electrode on head skin.
- light flash produces characteristic sequence of waves: after 26 ms – a wave (mediated by receptors) after 45 ms – b wave (mediated by ganglion cells) c wave (generated in pigment epithelium).
- useful in diagnosis of: 1) diseases in which retina visualization is difficult because ocular fluids are cloudy.
2) congenital retinal dystrophies in which retina appears normal by ophthalmoscopy.
- ERG may persist in absence of VEP in brain death.

INTRAVENTOUS FLUORESCIN ANGIOGRAPHY (IVFA)
- does not rely on ionizing radiation! IV fluorescein solution → rapid-sequence photography by using camera with spectral excitation and barrier filters.
- fluorescein does not cross blood-retinal barrier (pigment epithelium and retinal capillaries are impermeable whereas Bruch membrane and choriocapillaris are freely permeable).
Indications - imaging retinal, choroidal, optic disc, or iris vasculature: retinal artery / vein occlusion, ischemic optic neuropathy, age-related macular degeneration.

Hyperfluorescence – leakage (fluorescein penetrates blood-retinal barrier and accumulates sub-, intra-, or pre-retinally), pooling (fluorescein accumulation in fluid-filled space in retina or choroid).

Hypofluorescence – blockage (optical density such as blood or pigment interposed between camera and choriocapillaris), vascular occlusion (nonfilling vessels cause hypofluorescence).

Normal intravenous fluorescein angiography:

BIBLIOGRAPHY for ch. “Ophthalmology" — follow this LINK >>