VS III: Ocular Motility and Binocular Vision
Spring 2007

Review of Pupils

I. Definitions
- Miosis
- Mydriasis
- Direct pupillary reflex
- Consensual pupillary reflex
- Near pupillary reflex
- Anisocoria
- Sphincter pupillae- smooth muscle; parasympathetic
- Dilator pupillae- smooth muscle; sympathetic

II. Interesting Pupil Facts:

- Purpose:
  - Modifies amount of light entering eye; increases sensitivity of eye
  - Increases depth of focus
  - Minimizes chromatic and spherical aberrations
- Newborns and the elderly are miotic (elderly 1/3 size of 20 yo)
- Miotic during sleep, with blinking, and with forced closure
- Retinal stimulation: larger response when foveal stimulation
- Accommodation and convergence can change pupillary size
- Physiological and emotional states can change pupillary size:

Dilation	Constriction
Sensory nerve Stimulation	Eye irritation (Trigeminal)
Vestibular stimulation	Sleepiness
Emotional stimulus	
Systemic pain	

- Various drugs can effect the pupils:
  - Parasympathomimetics
  - Sympatholytics
  - Parasympatholytics
  - Sympathomimetics

III. Innervational Pathways

A. Parasympathetic:
- **Light reflex**

  - Originates from any point on the retina as light stimulates it.
  - **Afferent pathway:**
    - Begins in the ganglion cell layer, through the optic nerve, then fibers decussate at the chiasm.
    - **Nasal** fibers of each retina **cross**, **temporal** ones **do not** cross.
    - Posterior to the chiasm, afferent fibers pass into the optic tract, then separate from the tract in its posterior third, just anterior to the LGN.
    - They enter the midbrain, then go to the pretectal nucleus.
    - Synapses occur in the pretectal nuclei, and the fibers hemidecussate through the posterior commissure and terminate in the **Edinger-Westphal nuclei.**

- **Efferent pathway**
  - Begins at the Edinger-Westphal nuclei.
  - **Parasympathetic** fibers of **CNIII** course through he inferior division of the nerve when it bifurcates in the cavernous sinus.
  - In the sinus, CN III is closely related to the first and second divisions of CN V.
  - CN III enters the orbit through the superior orbital fissure and synapses at the **ciliary ganglion**.
  - **Postganglionic** fibers pass to the smooth muscle fibers of the **iris sphincter** through the short ciliary nerve. These nerves travel forward in the suprachoroidal space and release **acetylcholine** at the neuromuscular junction.

******Clinical note****** If one of the afferent pathways is affected, you will see an APD during your pupillary testing. However, be sure to R/O other factors that can simulate a false APD: amblyopia, a previously patched eye, a tilted light source directed off the macula. Efferent pupillary defects can be part of a III N palsy or internal ophthalmoplegia.

Near reflex:

- Initiated by the attempt to fixate a near object.
- Triad of responses occurs: **convergence, accommodation, and miosis**, called the **NEAR TRIAD**.
- The afferent path is similar to that of the light reflex back to the posterior third of the optic tract. Fibers then pass to the occipital cortex, through the prestriate area to the premotor area of the **frontal lobe**.
- From here, the fibers pass through the corona radiata and internal capsule to the **oculomotor nucleus (CN III).**
- Efferent path from the oculomotor nucleus is likely the same as the light reflex, although it is possible that a separate path for near fibers may exist, and that these fibers do not form a synapse in the ciliary ganglion. The final path is through the third nerve directly, or through the ciliary ganglion to the **ciliary** and **sphincter pupillae muscles**.

*********Clinical Note******** **Argyll** Robertson Pupil (Light-near dissociation) occurs along this pathway, for the near reflex fibers are more ventrally located than the light fibers. This means that a lesion can impact the afferent light reflex fibers but not the near reflex fibers. Argyll-Robertson pupils are small and irregular and do not react to light, but have a brisk nearpoint response. The cause is usually syphilis.

***Clinical note: Parinaud's syndrome involves light/near dissociation (Argyll-Robertson pupil), paralysis of upward gaze, and lid retraction (which may look like a ptosis on the opposite eye!) Caused by a dorsal midbrain problem, possibly a pinealoma. Refer for a CT or MRI to rule this out.

B. Sympathetic:

Pupillodilator pathway

- Begins with afferent impulses from the cortex that terminate in the hypothalamus.
- Sympathetic outflow then begins in the posteriolateral area of the hypothalamus, and the preganglionic fibers pass uncrossed through the tegmentum of the midbrain and pons.

- These **preganglionic** fibers then pass through the lateral portion of the medulla and terminate in the **dilator** center of the spinal cord, lying in the lateral column of the cord at the junction of the thoracic and cervical regions (at the C8 to T2 level→ the **ciliospinal center of Budge**).
- Fibers exit the cord in this area, passing through the white rami communicans of the uppermost thoracic nerves and up the cervical sympathetic trunk.
- Fibers then reach the **superior cervical ganglion** at the base of the skull, where the first synapse takes place.
  - **Postganglionic** fibers run upwards around the **internal carotid artery** and eventually join the trigeminal ganglion, passing into the orbit through the nasociliary nerve and enter through the long ciliary nerves, terminating in the **iris dilator**.

Clinical note** Horner's Syndrome involves a **sympathetic pathway** lesion and has a clinical triad of ptosis, miosis, and anhydrosis. The site of the lesion can be life threatening, so be sure to do your differential pharmacological testing!

- Signs of Horner's syndrome: anisocoria greater in dim illumination (because small pupil doesn't dilate as well as the larger, normal pupil).
- Causes of Horner's syndrome:
  - First-order neuron: Stroke (vertibrobasilar artery problem or infarct)
    Tumor
    Severe osteoarthritis of the neck
    MS
    Trauma
    **Pt has sudden onset vertigo and sensory defects
  - Second-order neuron: Lung tumor or breast metastasis
    Trauma
    Thyroid adenoma
    Neurofibroma
    **If also arm pain, then suspect pancoast tumor
  - Third order neuron: Headache/migraine (esp. IPSI)
    Cavernous sinus tumor
    Skull fracture
    Herpes zoster
    Otitis media
  - Congenital Horner's: trauma during delivery (may also have iris heterochromia)

Other pupil anomalies:

- Adie's Tonic Pupil
  - Occurs usually in young women 20-40 yo
  - Blurry unilateral VA at near
  - Anisocoria(Adie's pupil is larger)
  - Recent URI
  - Pupil responses:
  - Vermiform segmental pupil
  - Slow/tonic near response, greater than light response
  - Smaller with time
  - Deep tendon reflexes diminished
  - Decreased corneal sensation
  - Test with diluted Pilocarpine-eye is supersensitive to $1/8^{th}$ percent
    - Causes: Idiopathic
      Orbital trauma or infection
      Herpes Zoster
      Diabetes

Autonomic Neuropathies

****Clinical note***** The best place to observe an Adie's pupil is under the slit lamp. Focus your light on the pupillary margin and you will see it "ratchet" or squiggle as it tries to constrict.

- Physiologic Anisocoria
  - Pupil size disparity is same in dark and light, usually 1 mm
  - Normal pupillary reactions
  - No APD
  - Often there from birth

Case #1: Doctor, why are my baby's eyes weird?

S: 2-month-old male. Mother reports that the pupil of his left eye is smaller than the right one.

What questions are you going to ask her?

O: VA's: 20/200 with Teller cards
Pupils: Light OD: 3mm->1mm, OS 2mm->1mm
Dark OD: 5mm->1mm, OS 4mm->1mm
Alignment: intermittent left exotropia at near (about 30%)
NPC: unable to demonstrate convergence
EOM's: no restrictions, no misalignment
Stereo: unable to elicit with stereo smile
Retinoscopy: +0.50 OU Mohindra; some fluctuation in reflex
Adnexa and retina: no pathology noted, OU

What other tests do we need to do and WHY?

What are your differential diagnoses and WHY?

Based upon the information we have here, what is your best guess as to a final diagnosis?

Explain, in layman's terms, your diagnosis, your treatment, and your management of this patient.