What Pupils Tell Us About the Eye

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No Disclosures
Why Test Pupils

• When we test pupils we are checking to make sure there is no interruption in the neurological pathway responsible for the pupillary function.

• We are also checking for any mechanical defects that may be interrupting the pupils function
Pupillary Muscles

Dilator muscle of iris

Iris

Sphincter muscle of iris

Pupil
Flex Those Muscles

• Sphincter muscle fiber
  o When contracts causes constriction of pupil size
  o Controlled by parasympathetic system (sit and stare)

• Dilator muscle fiber
  o When contracts causes the pupil to enlarge (dilate)
  o Controlled by the sympathetic system (fight or flight)

• Must work together, to dilate the sphincter muscle has to relax and the dilator muscle must activate
How does it work?

• Pupillary Neurological Pathway
• The pupil reacts to both light and accommodation
  o Pupillary light reflex
  o Pupillary dark reflex
  o Pupillary accommodative response
• Remember. . . .

• AFFERENT ➔ RECEIVE INFO
• EFFERENT ➔ SEND INFO
• Miotic ➔ Constricted pupil
• Mydriasis ➔ Dilated pupil
Pupillary Light Reflex

• Pupils normally constrict with light
  o Consensual and direct response

• Neuron 1 Retina ➔ neuron 2 Pretectal nuclei ➔ neuron 3 Edinger-Westphal nuclei ➔ neuron 4 Ciliary ganglia

• Optic nerve (photosensitive ganglion cells) senses incoming light
  o Sends the information, Afferent portion of the pathway CN2
  o Fibers split at optic chiasm: lateral geniculate nucleus, contralateral pretectal nucleus

• Pretectal nuclei
  o Neuronal cell bodies connect to neurons in the EW nuclei, runs with oculomotor nerve (CN3)

• Edinger-Westphal nuclei
  o Efferent portion of pathway sends information to the iris muscle via CN3
  o Parasympathetic neuronal axons in CN3

• Ciliary ganglia
  o Post-ganglionic ciliary nerves travel from here to innervate the iris sphincter muscle
• Information goes in on cranial nerve II (optic nerve) and comes out on cranial nerve III (oculomotor nerve). This is a consensual (both eyes are involved) parasympathetic reflex. If only the eye illuminated constricts then there is damage to the crossing fibers, i.e. damage in the midbrain.
Pupillary Dark Reflex

- Pupils normally dilate when it's dark
  - Relaxation of the iris sphincter and contraction of the iris dilator muscle
- Iris dilator muscle is controlled by the sympathetic nervous system
- Retina → hypothalamus → sympathetic preganglionic neurons on spinal cord → superior cervical ganglion → sympathetic postganglionic in long ciliary nerve → Iris dilator
Pupillary Accommodative Response

• Occurs when switching gaze from a distant object to a near object
  o Consensual response
  o Triad: pupil accommodation, lens accommodation, convergence in accommodation

• Afferent
  o Optic nerve → lateral geniculate body → visual cortex

• Efferent
  o Edinger-Westphal nucleus → ciliary ganglion → via short ciliary nerve iris sphincter and ciliary muscle/zonules (lens) → pupil constriction
  o At the same time
  o Ocumotor neurons → medial rectus → convergence
How to Test

• Measuring the size of pupils should be done in both light and dim conditions
  o This will tell us if the patient has equal size in one situation and not the other.
  o If the patient has anisocoria, this will also help to determine if it is congenital or not.
  o For lighted conditions turn on overhead lights, don’t put lights directly into patients eye.
  o For dim conditions turn off the main overhead and use the dimmer lights.
Measure like this . . . . .
When to Measure Pupil Size

• Every patient... but especially

• When a patient presents with pupils that are both different sizes
  o Note if both are reactive by measuring in both dim and light illumination
  o If you note that one is not reactive still measure in both dim and light illumination
Like this. . . .
Direct light Reaction

• Check for direct constriction (pupil with the light source) and consensual constriction (dilation of the pupil that does NOT have the light source) response on each eye
• Perform in a semi-darkened room using either a transilluminator or a penlight.
NORMAL REACTION

Right Eye

Left Eye

Light source
Pupils and Accommodation

- Check patients near reflex next, in still semi-darkened room.
  - Fixate first on distant object (letter on chart), then have them fixate on a near object about 40 cm from their face (end of PD ruler/Near card letters).
  - You are looking for constriction of the pupil
    - Don’t need to measure
NEAR/
ACCOMMODATIVE
REACTION

Right Eye          Left Eye

Far Object

Near Object
Even if your patient looks like this...
How to Test swinging flashlight test

• Next perform the swinging flashlight test with the pt fixated on distance target in semi-darkened room
  o First illuminate OD, then swing the light to OS.
  o Repeat several times, illuminating each pupil for about 3 seconds.
  o Some APD’s may have a sluggishly constricting pupil so don’t go too fast.
ABNORMAL REACTION: APD OD

Light source

Right Eye

Left Eye
Grading APD

• Grade 1+-4+
  o Based on how the eye that the light is directly on reacts
  o Trace APD
    • Pupil has an initial constriction but then blows back out to larger intermediate position than the other eye
  o 1-2+ APD
    • No change in pupil size initially, then dilates (may be sluggish)
  o 3-4+ APD
    • Immediate dilation of affected pupil
Teasing Out an APD

• Using filters (like the ones in our stereo glasses)
  o Place a neutral density filter over the good eye
    • Creates a defect on the good eye
    • Try different (higher density/darker) filters until both eyes react the same as when performing swinging flashlight test
Physiological Anisocoria

- Most common cause of difference in pupillary size
- Approximately 20% of population
- Amount can vary from day to day
- Same amount inequality in both light and dark
- No APD present
Hippus

- Spasmodic or rhythmic contraction like movement
- Alternating contraction by the sphincter and the dilator muscles
- Tends to be random, whereas a true APD is consistent between trials
- Is NOT usually indicative of neurological problem!
Come on is it really that important?
Relative Afferent Pupillary Defect (RAPD)

- Disruption in the any of the following:
  - Retina
    - unilateral macular scar, retinal detachment
  - Optic nerve
    - AION, NAION, Optic neuritis, amblyopic eye, CRAO, CRVO
  - Chiasm (RARE, if asymmetric visual fields)
  - Optic tract: contralateral RAPD
    - Vascular
  - Superior brachium: contralateral
Most Common Causes of APD

• Complete 3rd Cranial Nerve Palsy
• Horner’s Syndrome
• Optic Nerve Damage
• Damage to the Efferent Pupillary pathway
  o Adies Tonic Pupil
  o Argyll Robertson Pupil
• Pharmacological causes (Pseudo APD)
Complete Third Nerve Palsy

- Eye is turned “down and out”
- Eyelid is shut
- Possible pupil involvement
  - Pupil sparing (normal reaction)
  - Non-Pupil sparing (affected pupil is not reactive to light shone in either eye)
Nobody loves you when you're down and out.
Pupil involvement

• Pupil involvement implies likely tumor/aneurysm (most concerning)
  o Something pressing on the nerve from outside
• Non-Pupil involvement implies likely diabetes/HTN/ischemia (most common)
  o Something pressing on nerve from inside

...sort of

• Pt will get an MRI either way to be safe
Horner’s Syndrome: Sympathetic Lesion

- Horner's is caused by blockage of signal somewhere in its sympathetic pathway.
  - Can be caused by:
    - Carotid artery decussation
    - Chemicals
    - PanCoast Tumor
Horner’s Syndrome: Sympathetic Lesion

• Clinical Presentation:
  o Affects one side of patient
  o Ptosis (a few mm lower than fellow eyelid)
  o Miosis (smaller pupil, especially in dim light)
  o Anhydrosis (dry, red skin around the eye/forehead cheek on that side)
  o Heterochromia
    • (if onset prior to first 2 years of life)
Denervation Supersensitivity

• Lack of stimulation makes a nerve super sensitive
• This principle is applied in using medications to determine where the problem lies (roughly)
  o These patients should be seen by the doctor before dilation
  o **4 or 10% Cocaine**: blocks reuptake of norepinephrine at sympathetic nerve synapse
    • 1 hour after instillation of 2 gtt's
      o Both eyes dilated → No Horners
      o One eye dilated other miotic → Horners
        • Miotic eye = Affected eye
Sometimes it’s a little hard to find cocaine... So there's an alternative method!

0.5% Apraclonidine (Iopidine): direct alpha-adrenergic agonist, concept of alpha-1 receptor denervation supersensitivity

- 1-2 gtt
- No lesion: NO DILATION
- Lesion: DILATION
  - Supersensitive receptors react to apraclonidine and cause dilation
Lesion Localization

• Lesion location: pre vs post-ganglionic
  o 1% Hydroxyamphetamine: releases stored NE from postganglionic adrenergic nerve endings
    • Must wait 24-72 hours after cocaine/iopidine
    • Effect is seen 1 hour after instillation of 1 gtt

-OR-

• 1% Phenylephrine: concept of denervation supersensitivity
  o Must wait >24 hours after cocaine/apraclonidine
  o 1 gtt, wait 15-20 min
  o Pre-ganglionic lesion: NO DILATION
  o Post-ganglionic lesion: DILATION
Optic Nerve Damage

Damage to the Afferent Pupillary Pathway will cause poor constriction:

- Optic Neuritis
- Glaucoma
- Trauma
Optic Neuritis

- Inflammation in the optic nerve
  - MS – Multiple Sclerosis
  - AION – Anterior Ischemic Optic Neuropathy
- Will causes pain and temporary vision loss
- Long-term damage to the nerve fibers results in VF loss, photosensitivity, red cap desaturation, APD
Glaucoma

- Damage and loss of RNFL/optic nerve fibers over time causes constriction of visual field and damage to vision
  - Severe end stage glaucoma
    - Will often have poor vision and an APD
Optic Nerve Damage

- Trauma
  - Similar to both glaucoma and optic neuritis, can have loss of RNFL or optic nerve function
  - Decrease in contrast sensitivity and light sensitivity
    - APD
Tonic Pupil

Damage to Efferent Pupillary Pathway will cause poor *dilation* in LIGHT conditions:

- **Adie’s Tonic Pupil**
  - Damage to the ciliary ganglion (remember that area in the brain that sends the information to the muscles)

- **Argyll-Robertson Pupil**
  - Will constrict with accommodation (near objects) but not light
  - Related to neurosyphilis
Adie’s Tonic Pupil: Ciliary ganglion lesion

- Clinical presentation
  - Unilateral mydriasis (dilation)
  - Poor or absent light reaction (tonicity)
  - Segmental palsy of sphincter
  - Accommodation paresis (tends to recover)
  - Slow pupil constriction to accommodation, slow redilation (tonicity)
  - Occasional “ciliary cramp” with near work
  - Occasionally regional cornea anesthesia (trigeminal fibers)
Tonic Pupil

LIGHT:

DARK:

Larger difference

Looks more equal

Picture Credit: Cincinnati VAMC Kelly Thompson OD FAAO
Adie’s pupil: Ciliary ganglion lesion

- **Epidemiology**
  - Mean age: 32
  - Females

- **Causes**
  - Idiopathic: 90%
  - Local disorders w/in orbit: tumor, inflammation, trauma, surgery, or infection
  - A/w underlying systemic autonomic neuropathies

“Cilly ladies get Adie’s”
Adie’s Pupil

- Pharmacological diagnosis
  - 0.125% Pilocarpine, 1 gtt OU
  - Cholinergic supersensitivity
    - Miosis of Adie’s pupil
  - Caveats:
    - Cholinergic supersensitivity not uniformly present in tonic pupil (80%)
    - Not specific for postganglionic parasympathetic denervation (also been reported after preganglionic lesions of third nerve)
    - Acute Adie’s may not have had time to develop supersensitivity (how soon: unknown, cats: 5-7 days)
Argyll-Robertson Pupil

- Bilateral miotic pupils that do not respond to light stimulation but normal pupillary constriction during accommodation for near objects
- Associated with neurosyphilis
  - Confirm with blood work
- Lesion within the midbrain likely in the Edinger-Westphal nucleus
Near-Light Dissociation

LIGHT
Right eye is tonic pupil

Near Target
NOTICE both pupils constrict

Picture Credit: Cincinnati VAMC Kelly Thompson OD FAAO
Pseudo APD

- Dilation drops
- Scopolamine patches
- Certain fertilizers and bug repellants
Practice Makes Perfect!

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