Basics of Strabismus testing

Laura May, CO
Madison Kincade
Strabismus

• Strabismus is any misalignment of the eyes
• Estimated that 4% of the U.S. population has strabismus
• Commonly described by the direction of deviation
• Can be described by cause of strabismus
Types of Strabismus

• Esotropia = ET
  – E(T), E

• Exotropia = XT
  – X(T), X

• Hypertropia = HT
  – H(T), H

• Dissociated Vertical Deviation = DVD

• Measurements at near use ‘ symbol
Testing Techniques

Cover tests

- Cover-uncover test
- Alternate prism cover test
- Simultaneous prism cover test
- Patch test (Marlowe)

https://ohioamblyopenregistry.com/about/
Cover Test
Uncover Test
Alternate Prism Cover Test

25 PD
Alternate Prism Cover Test

30 PD
Simultaneous Prism Cover Test

6 PD
Simultaneous Prism Cover Test

10 PD
Estimation Techniques

- Hirschberg
- Krimsky
Angle Kappa

• The angle between the visual axis and the pupillary axis
Motor fusion

• Types and normal ranges
  – Convergence
    • Near: 35-40 pd
    • Distance: 20-25 pd
  – Divergence
    • Near: 15pd
    • Distance: 7pd
  – Vertical vergence
    • 2-3 pd (base up/down)
  – Cyclovergence
    • 1-2 degrees

Vergences

Simultaneous control of eyes in opposite direction

Convergence
1. Tonic – constant innervation tone to the EOM while awake
2. Accommodative – near reflex, near triad
3. Fusional – stimulus to maintain clear, single image
4. Relative – amount of BO prism person can handle
5. Proximal – controlled by awareness of near
6. Voluntary – ability of eyes to converge without stimulus

Divergence
1. Tonic
2. Fusional
3. Relative

Vertical
1. Tonic
2. Fusional
NPC/NPA

- Near point of convergence (NPC)
  - Accommodative target moved towards patient’s nose, break point recorded when patient becomes XT
  - 10cm or less = normal

- Near point of Accommodation
  - Prince rule used to measure
  - Tested monocular and binocularly

http://www.west-op.com/berensaccommod.html
Binocular Vision

• Worth 4 dot
  – SBV
  – Suppression
  – Diplopia

• Titmus Fly
  – Stereo
  – Monocular clues
Bagolini Striated Lenses

• Bagolini lenses test for:
  – Diplopia (ET/XT)
  – Fusion or Harmonious ARC
  – Suppression Scotoma
  – Suppression
Detection and measure cycloptropia

- Double maddox rods
- Synoptophore
- Bagolini lens
- Fundus photography

http://www.ophthalworld.de/ishop/showdetail,2004g.en,.vorhalter_und_leisten.neue_vorhalter_und_leisten,01130,8,showrub--vorhalter_und_leisten.neue_vorhalter_und_leisten.htm
Diplopia

• Testing in clinic
• Monocular vs. Binocular
• Treatments
  – Fresnel prism/ground in prism
  – Fogging/occlusion

http://www.medicalnewstoday.com/articles/170634.php
http://www.eyecareandcure.com/ECC-Products/Occluders-Maddox-Rods
AC/A ratio

- Gradient
- Heterophoria

\[ AC/A = \frac{\Delta_1 - \Delta_0}{D} \]

\[ AC/A = PD + \frac{\Delta_n - \Delta_0}{D} \]
Prism adaptation test

• Uses
  – Determine position of motor stability with acquired ET
  – Determine fusion potential
  – Determine risk of surgical over-correction

Extraocular Muscles

http://marineyes.com/anatomy/muscles.html
Extraocular Muscles

- **Agonist**: primary muscle that is moving eye
- **Antagonist**: opposite muscle that is relaxing in the same eye
- **Synergist**: muscle helping the eye move along with the agonist
  - Ispilateral synergist: same eye
  - Contralateral synergist: opposite eye – Yoke pair
- **Contralateral Antagonist**: opposite eye that antagonist of the yoke pair in that eye
Extraocular Muscles

• **Herring’s Law**: innervation to the EOM generated by yoke pairs/contralateral synergist.

• **Sherrington’s Law**: reciprocal innervation.

• **Listing’s Law**: no torsion occurs.

• **Donder’s law**: torsion is produced.
Yoke Muscles
# Extraocular Muscles

<table>
<thead>
<tr>
<th>Muscle</th>
<th>Primary Action</th>
<th>Secondary Action</th>
<th>Cranial Nerve Innervation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lateral Rectus</td>
<td>Abduction</td>
<td>None</td>
<td>6&lt;sup&gt;th&lt;/sup&gt; CN</td>
</tr>
<tr>
<td>Medial Rectus</td>
<td>Adduction</td>
<td>None</td>
<td>3&lt;sup&gt;rd&lt;/sup&gt; CN</td>
</tr>
<tr>
<td>Superior Rectus</td>
<td>Elevation</td>
<td>Adduction, intorsion</td>
<td>3&lt;sup&gt;rd&lt;/sup&gt; CN</td>
</tr>
<tr>
<td>Inferior Rectus</td>
<td>Depression</td>
<td>Adduction, extorsion</td>
<td>3&lt;sup&gt;rd&lt;/sup&gt; CN</td>
</tr>
<tr>
<td>Superior Oblique</td>
<td>Intorsion</td>
<td>Depression, abduction</td>
<td>4&lt;sup&gt;th&lt;/sup&gt; CN</td>
</tr>
<tr>
<td>Inferior Oblique</td>
<td>Extorsion</td>
<td>Elevation, abduction</td>
<td>3&lt;sup&gt;rd&lt;/sup&gt; CN</td>
</tr>
</tbody>
</table>
# Cranial Nerve Palsies

## Common causes of CN palsies

<table>
<thead>
<tr>
<th>Nerve</th>
<th>Childhood</th>
<th>Adult life</th>
<th>&gt; 55yr</th>
</tr>
</thead>
<tbody>
<tr>
<td>3rd</td>
<td>Trauma</td>
<td>Intracranial aneurysm</td>
<td>Hypertension and diabetes</td>
</tr>
<tr>
<td>4th</td>
<td>Trauma</td>
<td>Trauma</td>
<td>Trauma</td>
</tr>
<tr>
<td>6th</td>
<td>Idiopathic, isolated benign, increased ICP, Trauma</td>
<td>MS, Space occupying lesion, Trauma</td>
<td>Hypertension, diabetes, space occupying lesion</td>
</tr>
</tbody>
</table>
Ocular rotations

Ductions vs Versions
Ductions

Horizontal Ductions

- Primary
- Adduction
- Abduction

Vertical Ductions

- Supraduction
- Infraaction

Cyclo-Ductions

- Excycloduction
- Incycloduction
Objective measurements

• Distance and near fixation
• Nine diagnostic positions of gaze
• Head tilts
• Three-step test

[Diagram of oculomotor measurements]
Pattern Strabismus

• A-pattern
  – Increasing ET or decreasing XT in up gaze
  – Decreasing ET or increasing XT in down gaze
  – A pattern must have 10 pd of incomitance

• V-pattern
  – Increasing XT or decreasing ET in up gaze
  – Decreasing XT or increasing ET in down gaze
  – V pattern must have 15 pd of incomitance
“VAVA”

- V-ET – most common
- A-ET – most common in patients with Down syndrome
- V-XT
- A-XT – least common

## Abnormal Head Postures

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Ocular</th>
<th>Non-ocular</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cover test</td>
<td>Abnormal EOM</td>
<td>Normal motility</td>
</tr>
<tr>
<td>Straighten head</td>
<td>- Able to passively straighten head</td>
<td>Unable to passively straighten head</td>
</tr>
<tr>
<td></td>
<td>- Longstanding AHP more difficult</td>
<td></td>
</tr>
<tr>
<td>Occlusion</td>
<td>When one eye occluded, head will straighten</td>
<td>When one eye occluded no change in AHP</td>
</tr>
<tr>
<td>Facial Asymmetry</td>
<td>No or slight facial asymmetry</td>
<td>Marked facial asymmetry</td>
</tr>
<tr>
<td>Head position</td>
<td>Turn and tilt vary depending on muscle</td>
<td>Tilt and turn to side of contracted sternocleidomastoid muscle</td>
</tr>
<tr>
<td></td>
<td>affected</td>
<td></td>
</tr>
</tbody>
</table>
Esotropia

http://www.pedseye.com/strabismus_esotropia.htm
# Esotropia

<table>
<thead>
<tr>
<th>Infantile</th>
<th>Acquired</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Congenital</strong></td>
<td><strong>Accommodative Esotropia</strong></td>
</tr>
<tr>
<td>Nystagmus blockage syndrome</td>
<td>Non accommodative Esotropia</td>
</tr>
<tr>
<td>Ciancia Syndrome</td>
<td>Acute comitant Esotropia</td>
</tr>
<tr>
<td><strong>Duane’s Syndrome</strong></td>
<td>Cyclic Esotropia</td>
</tr>
<tr>
<td><strong>Abducens palsy</strong></td>
<td>Sensory Esotropia</td>
</tr>
<tr>
<td>Moebius Syndrome</td>
<td>Divergence Insufficiency</td>
</tr>
<tr>
<td></td>
<td>Divergence Paresis</td>
</tr>
<tr>
<td></td>
<td>Spasm of near reflex</td>
</tr>
<tr>
<td></td>
<td>Medial rectus restriction</td>
</tr>
<tr>
<td></td>
<td>Lateral rectus weakness</td>
</tr>
<tr>
<td></td>
<td>Consecutive and secondary Esotropia</td>
</tr>
<tr>
<td></td>
<td>Small angle Esotropia</td>
</tr>
<tr>
<td></td>
<td><strong>Monofixation Syndrome</strong></td>
</tr>
</tbody>
</table>
Esotropia

• Classification
  – Age of onset
    • Infantile
    • Acquired
  – Role of accommodation and refraction
    • Non-accommodative
    • Refractive
    • High accommodative convergence to accommodation ratio
    • Partially accommodative
Psuedoesotropia

- Prominent epicanthal folds
- Narrow interpupillary distance
- Negative angle kappa
- Enophthalmos
- Craniofacial malformations
Congenital Esotropia

- Onset near birth
- Usually large angle > 30PD
- Associated vertical deviations common
- Latent nystagmus
- Cross fixation
Accommodative Esotropia

• Onset age 6mo – 7yrs, average 2.5yrs
• Moderate to high hyperopia
• May be only partially accommodative
• May have a high AC/A
• Can be intermittent or variable
• May decompensate
Duane’s Syndrome

- Congenital miswiring of LR muscle with the branches from the medial rectus subnucleus
- 3 clinical types
- PF changes
- Globe retraction

| TABLE 1 |
| CLINICAL TYPES OF DUANE’S SYNDROME

<table>
<thead>
<tr>
<th>Type</th>
<th>Abduction</th>
<th>Adduction</th>
<th>Retraction</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Limited</td>
<td>Full</td>
<td>Present</td>
</tr>
<tr>
<td>2</td>
<td>Full</td>
<td>Limited</td>
<td>Present</td>
</tr>
<tr>
<td>3</td>
<td>Limited</td>
<td>Limited</td>
<td>Present</td>
</tr>
</tbody>
</table>
6th CN Palsy

• Signs and Symptoms
  – Limitation in abduction
  – Ductions > versions
  – D ET > N ET’
  – Face turn toward paretic eye
  – ET larger in affected gaze
  – Can be unilateral or bilateral

http://entokey.com/neuro-ophthalmology-6/
# Duane’s vs VI palsy

<table>
<thead>
<tr>
<th>Clinical Characteristics</th>
<th>Type 1 Duane's</th>
<th>VI Nerve Palsy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Complete absence of abduction</td>
<td>Typical</td>
<td>Not Always</td>
</tr>
<tr>
<td>Large ET in primary</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Globe retraction in adduction</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Lid fissure widening on abduction</td>
<td>Yes</td>
<td>Possible</td>
</tr>
<tr>
<td>Upshoot/downshoot</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Diplopia</td>
<td>Rare</td>
<td>Yes</td>
</tr>
<tr>
<td>Greater ET at distance</td>
<td>Rare</td>
<td>Common</td>
</tr>
</tbody>
</table>
Monofixation Syndrome

- Small manifest ET
- Central scotoma
  - 4 BO test
    - 4 BO prism held in front of either eye, watch for a shift and convergence
- Mild amblyopia common
- Reduced stereoacuity
Exotropia

# Exotropia

<table>
<thead>
<tr>
<th>Infantile</th>
<th>Acquired</th>
</tr>
</thead>
<tbody>
<tr>
<td>Congenital exotropia</td>
<td>Intermittent exotropia</td>
</tr>
<tr>
<td>Sensory exotropia</td>
<td>Secondary or consecutive exotropia</td>
</tr>
<tr>
<td></td>
<td><strong>Convergence insufficiency exotropia</strong></td>
</tr>
<tr>
<td></td>
<td>Third nerve palsy</td>
</tr>
<tr>
<td></td>
<td>Duane syndrome type 2</td>
</tr>
<tr>
<td></td>
<td>Sensory exotropia</td>
</tr>
</tbody>
</table>
Exotropia

• Classification
  – Age of onset
    • Infantile
    • Acquired
  – Distance-near relationship
    • Basic (D=N)
    • Divergence excess (D>N)
    • Pseudo-divergence excess
    • Convergence insufficiency (N>D)
Psuedoexotropia

- Positive angle kappa
- Wide interpupillary distance
- Wide palpebral fissures
- Exophthalmos
- Narrowing lateral canthi
- Hypertelorism
Congenital Exotropia

- Onset by age 6 months
- Associated vertical deviations
- Large angle > 30pd
- Latent nystagmus
- May have associated neurological abnormalities
X(T)

- Broken down X
- Monocular lid closure
- Wider VF
- No diplopia
- Control
  - Good, fair, poor

Convergence insufficiency

• Characteristics
  – Reduced convergence amplitudes
  – May c/o headaches, asthenopia and eye strain
  – May have intermittent diplopia
  – May have reduced NPC
Convergence insufficiency

- Treatments
  - Pencil pushups
  - Stereogram
  - Computer orthoptics
  - Prisms

http://computerorthoptics.com/
3<sup>rd</sup> Cranial Nerve

- 3<sup>rd</sup> CN
  - Superior division innervates
    - Superior rectus
    - Levator
  - Inferior division innervates
    - Inferior rectus
    - Inferior oblique
    - Medial rectus
    - Intraocular muscles
3rd CN Palsy

• Characteristics
  – Ptosis
  – Dilation of pupil
  – Limitation of adduction, elevation and depression
  – Exotropia and hypotropia in primary
  – Accommodative weakness
  – May present as isolated extraocular muscle palsy
Vertical Strabismus

http://www.cehjournal.org/article/understanding-detecting-and-managing-strabismus/
# Vertical Strabismus

<table>
<thead>
<tr>
<th>Paretic</th>
<th>Muscle Restriction</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>SO palsy</td>
<td>Brown syndrome</td>
<td>DVD</td>
</tr>
<tr>
<td>IO palsy</td>
<td>Monocular Elevation Deficiency</td>
<td>Myasthenia Gravis</td>
</tr>
<tr>
<td>SR palsy</td>
<td>CPEO</td>
<td>Skew Deviation</td>
</tr>
<tr>
<td>IR palsy</td>
<td>Congenital fibrosis</td>
<td>PSP</td>
</tr>
</tbody>
</table>
4th CN Palsy

- Superior Oblique Palsy
  - Hypertropia of affected eye
  - AHP is common
  - Excylotorison
  - Positive Bielschowsky head tilt test
  - Can be congenital or acquired
  - Unilateral or bilateral
## 4th CN Palsy

<table>
<thead>
<tr>
<th></th>
<th>Congenital/long standing</th>
<th>Acquired</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diplopia</td>
<td>Rare</td>
<td>Present, but can be limited to paretic field</td>
</tr>
<tr>
<td>Image tilting</td>
<td>Absent</td>
<td>Common</td>
</tr>
<tr>
<td>Comitance</td>
<td>Spread may obscure paresis</td>
<td>Characteristically incomitant</td>
</tr>
<tr>
<td>Abnormal head posture</td>
<td>May persist on covering eye due to contracture</td>
<td>Disappears on covering eye</td>
</tr>
<tr>
<td>Facial Asymmetry</td>
<td>Common</td>
<td>Absent</td>
</tr>
<tr>
<td>Past pointing</td>
<td>Absent</td>
<td>Present</td>
</tr>
<tr>
<td>Old photos</td>
<td>May show AHP</td>
<td>Negative</td>
</tr>
<tr>
<td>Amblyopia</td>
<td>May be present</td>
<td>Absent</td>
</tr>
</tbody>
</table>
Unilateral vs Bilateral 4th

• Bilateral SO palsy
  – V pattern present
  – 10 degrees of excyclotorsion, may increase in downgaze
  – Reversal of HT on side gazes, tilts or oblique fields
  – ET maybe associated
Bilateral 4th CN Palsy
Parks–Bielschowsky three-step test
Brown Syndrome

Brown Syndrome

- Inability to elevate in adduction
  - Duction = version
- Hypotropia in primary and/or upgaze
- Divergence on upgaze, V pattern
- Etiology
  - Congenital, traumatic, inflammatory, iatrogenic
IO palsy

• Inferior division of 3rd CN, look for MR, IR and pupil involvement
• Test with 3 step test
• Overaction of ipsilateral SO
• AHP – turn to opposite side, tilt to affected side
• Differential dx = Brown’s syndrome
# Brown vs IO palsy

<table>
<thead>
<tr>
<th>Clinical Characteristics</th>
<th>Brown Syndrome</th>
<th>IO Palsy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Limitation of elevation in adduction</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Overaction of ipsilateral SO</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Versions = Ductions with elevation in adduction</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Positive forced ductions</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Positive forced generations</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Positive head tilt test</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Pattern</td>
<td>V</td>
<td>A</td>
</tr>
<tr>
<td>Incyclotorsion</td>
<td>No</td>
<td>Yes</td>
</tr>
</tbody>
</table>
• Up-drift of eye occurring under cover or spontaneously during visual inattentiveness

• Associated with:
  – early disruption of binocular development
  – Latent nystagmus
  – Horizontal infantile strabismus
  – Poor binocular VA

• No associated HypoT deviation
Conclusion

• Types of strabismus
  – Horizontal/vertical
  – Dissociated deviations

• Testing techniques
  – Cover tests
  – Special testing

• EOM
Questions?