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Paediatric Balance Assessment

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overview

• The balance system
• Vestibular disorders
• referrals
• Vestibular assessment
  – History
  – Vestibular tests
  – Rehabilitation
How we balance:

**Input**
- Visual
- Rotation
- Gravity
- Pressure

**Output**
- Ocular reflex
- Postural control

Nausea
Semicircular canals

The vestibular system has two parts: the otolith organs and the semicircular canals. Each has different functions.

The canals detect the head’s rotation (angular acceleration).
Otolith organs

The vestibular system has two parts; the otolith organs and the semicircular canals. Each has different functions.

The otolith organs have two functions:

1. They sense the head’s translation (linear acceleration).

2. They are also able to sense the head’s position relative to gravity. These are the organs that tell us which way is down.
How we balance

**Input**
- Visual
- Rotation
- Gravity
- Pressure

**Output**
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- Postural control
- Nausea
Vestibular-ocular reflex (VOR)

The otoliths and canals activate many reflexes.
A key reflex is the vestibular-ocular reflex (VOR).

The function of the VOR is to stabilize the retinal image during rotations of the head.

This requires maintenance of stable eye position in space during any head translation or rotation.

For example, when the head rotates with a certain speed and direction, the eyes should rotate with the same speed but in the opposite direction.
Vestibular disorders

- A number of disorders can cause the balance system to stop working or provide inappropriate information. These include:
  - Migraine,
  - Menieres,
  - labyrinthitis,
  - benign paroxysmal positional vertigo (BPPV),
  - ear infections,
  - tumours,
  - trauma,
  - meningitis,
  - metabolic disorders (e.g., diabetes),
  - ototoxic medications, neurological disorders (e.g., cerebral palsy, hydrocephalus),
  - genetic syndromes (e.g., branchio-otorenal syndrome, Mondini dysplasia),
  - posterior brain tumours (e.g., malignant medullo-blastomas or benign acoustic neuromas), and a
  - family history of vertigo, motion sensitivity, hearing loss, or vestibular disorders.
Vestibular disorders in children

- Vestibular disorders in children are considered less common than in adults. However, children can potentially have the same disorders as in adults and this can impact on child’s development.

- Vestibular disorders are not as easily recognized in children as in adults, in part because children cannot describe their symptoms as well.

- Approximately 8% of children will complain of dizziness (Niemensivu et al 2006).
Causes of vestibular dysfunction in children

• In childhood most common are:
  – **Benign Paroxysmal Vertigo** (25% of vertigo in children)- migraine equivalent.
  – **Chronic O.M.E.** can lead to a vestibular problem.

• Less common:
  – more unusual presentations like **Familial episodic ataxia**
  – **Genetic disorders such as Ushers type I**
  – Anoxia at birth
  – Meningitis
  – ototoxicity
  – CMV
  – Perilymph fistula
  – Enlarged vestibular aqueduct
Benign Paroxysmal Vertigo (BPV)

- Also known as Childhood Paroxysmal Vertigo—sometimes referred to as migraine equivalent

- A central vestibular disorder typically in children 2-12 years

- True spinning vertigo, nystagmus, nausea and vomiting
Vestibular development

• There are certain developmental stages we need to go through to become adapted to gravity
  – Righting (1-2 months) Acquires head control
  – Lifts head, aligns eyes (2 months)
  - Learns to sit (6-8 months)
  – Stands and walks (12-18 months)
  - Adult-type balance (10-12 years)

• Maturation of Balance
  – Integration of vestibular /visual /somatosensory information increases with age.
  – Children 18 mo to 3 yrs age are dependant on visual cues.
  – Vision critical at “transitional” periods to the next milestone (crawling to standing to walking).
  – Children 6- 12 yrs. have poor resolution of sensory/ visual conflict.
Referrals for vestibular testing

Worth testing for/ruling out vestibular involvement if:

- Delayed motor development
- Delayed walking
- Loss of postural control – Falls
- Episodes where pallor/ vomiting
- Investigating aetiology of hearing loss +/- balance symptoms
SCH vestibular assessment referral Guidelines

• **Age range:** 2 years to 16 years. (Hearing Services does not accept any referrals for patients over the age of 16 years).

• The following **contraindications** to vestibular testing should be considered:
  – history of cardiac problem
  – epilepsy
  – extreme anxiety
  – non-cooperation for testing

  N.B. The final decision regarding contraindications to testing may only be possible on the day of testing.

• We will accept **tertiary referrals** (i.e. from another consultant in a related field) for stand-alone vestibular assessment in a non-consultant led clinic (by a registered Clinical Scientist). We may then arrange a consultation with the Audiovestibular Physician if appropriate.

• Referrals from **other sources**, e.g. GP, audiologists, will be triaged into the most appropriate clinic, e.g. a Scientist or consultant-led clinic for initial evaluation of hearing and/or appropriateness of vestibular testing.
Sheffield Children’s Hospital Vestibular service

• 251 children/ young people seen for vestibular testing since 2009

• Age range: 2-18 years

• 125 Females: 126 males
Vestibular assessment

• History
• Clinical tests
• Vestibular testing
History taking

- Vertigo is difficult to describe and localize for patients especially children. Children frequently do not describe dizziness or vertigo. May get description from parent/ carer of:
  - Delayed motor development  delayed walking
  - Loss of postural control –Falls
  - episodes where loss pallor, vomiting
  - sense of being extremely frightened
  - may clutch furniture or express a sudden fear of the dark
  - recurrent episodes
- Most important is to get a description of the symptoms and how the symptoms affect the child’s life.
- We try and establish if the ‘dizziness’ is:
  - true rotational vertigo (i.e. is the sensation of the environment or oneself spinning), or
  - “light headedness”, or a transient feeling of imbalance
History

• Need to establish:
  – when the symptoms began
  – what activity were they doing at time
  – whether were they ill
  – Is there a sudden hearing loss

• When does the dizziness occur?
  -some of the time or all the time
  -if constant, is it always the same or varies?
  -if it varies, what makes it better or worse?
  - How many attacks have there been, is there any pattern?

• How long does the dizziness last?
  -seconds-minutes?
  -hours?
  -days-weeks?
Vestibular testing:
Patient information

Patient Leaflet

Patient DVD
Clinical tests

- Examination of **eye movements** - use small toys!
  - Conjugacy
  - Spontaneous / gaze-evoked pursuit
- Romberg
- Step test
- Heel-to-toe walking
- CTSIB
MCTSIB – Modified Clinical Test of Sensory Integration on Balance

- **Test Conditions**
  - Condition 1: Floor stable, eyes open (visual, somatosensory and vestibular info available)
  - Condition 2: Floor stable, eyes closed (vision info absent)
  - Condition 3: Floor unstable, eyes open (somatosensory info absent)
  - Condition 4: Floor unstable, eyes closed (somatosensory and visual info absent)

- **Protocol**
  Record 30s trial using stopwatch. Stop the trial and record the time if patient:
  - deviates from initial crossed-arm position
  - opens eyes during an ‘eyes closed’ trial
  - moves feet (takes a step) or requires manual assistance from tester to prevent loss of balance
Videonystagmography (VNG)
VNG allows the observation and recording of eye movements in various conditions and positions. We look for the presence of nystagmus: spontaneous or provoked.
Oculomotor tests

Saccades

Smooth pursuit
Gaze testing

• Looking to see if any nystagmus when looking in several gaze directions (forward, left and right) with and without fixation

• Presence of nystagmus (?>3°/sec, or consistent across several tests) indicates vestibular dysfunction

• Categorized according to Alexander’s Law (i.e. 1st degree, 2nd, 3rd)
Headshake

- Looking to see if any nystagmus following a vigorous horizontal shake of the head for 10 seconds

- Presence of nystagmus (> 3 beats / >3°/sec) indicates vestibular dysfunction / asymmetry
Caloric testing

- Test involves running water (1st warm, then cool) into each ear separately and measuring the resulting nystagmus
- May indicate an vestibular asymmetry or hypofunction
- Caloric testing has limitations and cannot be performed easily on young children
Caloric testing

- Peripheral vestibular system responds to a range of intensity and frequency of stimulation in real life.

- Caloric stimulation is equivalent to a low frequency movement of .002-.004Hz and acceleration of <10deg/sec2 (i.e. well below the level where VOR functions during daily activity). Therefore, no caloric response does NOT imply completely absent peripheral vestibular function.

- Alternatively, caloric responses can be within normal limits, but accompanied by a spontaneous or positional nystagmus, indicating peripheral pathology.
Rotational chair testing

• When the chair (and the head) rotates at a certain speed and direction, the eyes should move at the same speed in the opposite direction (slow phase of the nystagmus) with a corrective fast movement.

• This rotational nystagmus can be measured and compared for rotation in different directions and frequencies and compared to normative data.
Advantages of Rotational chair testing

• Due to the limitations of VNG testing, some patients may have normal VNG results, but still have peripheral involvement

• Additional measures are useful to expand the investigation of the peripheral system beyond the low frequencies

• Rotating chair is the principle way to investigate young patients (even young children and infants)
Sinusoidal rotation

• Chair moves sinusoidally whilst increasing the frequency of movement

• We can record the gain and the phase of the nystagmus for higher frequency movements (more natural) than caloric testing allows
Sinusoidal rotation nystagmus
Step rotation

- Chair accelerates in one direction, then rotates at a constant speed, then decelerates.
- The resulting nystagmus is compared for rotation CW and ACW and compared for asymmetry.
- The Time constant indicates whether any asymmetry or abnormality of central velocity storage.
- Reduced time constants may indicate either a unilateral or bilateral peripheral vestibular impairment, or a central vestibular pathology.
Step rotation nystagmus
Examples of how rotation test results contribute to diagnosis:

- Reduced calorics and rotational chair with no response <.16Hz, increasing to borderline normal responses by 1.28Hz, indicative of severe bilateral peripheral system paresis
  eg. Profoundly deaf child with no vestibular function.

- Normal VNG + normal caloric response, but with abnormal time constant and asymmetrical rotational responses supports peripheral system involvement
  eg child with partial vestibular weakness with high frequency movement only

- Normal VNG, cannot perform calorics, but abnormal time constant and asymmetry. Indicates peripheral involvement.

- Rotational responses can be useful to assess the extent of peripheral paresis and to monitor progression of peripheral involvement. Can rule out bilateral paresis quickly.
vHIT (video Head Impulse Test)

- A test of vestibular function that consists of monitoring eye movements as the patient fixates on a stationary target while the head is rotated right or left unexpectedly using small-amplitude high-velocity high-acceleration movements.

- Normal individuals can maintain a steady gaze but patients with deficient VOR cannot keep up with high-velocity head turns and generate "catch-up" or refixation saccades after head impulses toward the damaged side.

- Can be performed in the planes of lateral, right anterior/left posterior (RALP), right posterior/left anterior (LARP) canal pairs to provide independent assessment of all 6 semicircular canals.
Head Impulse Test – Catch-Up Saccades

- Catch-up saccades reposition the eyes on the target.
- Catch-up saccades that occur after head impulses are called overt saccades - overt saccades are visible
- Catch-up saccades that occur during head impulses are called covert saccades - covert saccades are practically impossible to detect without specialized equipment
VEMP

• Gives additional information about the vestibular system other than horizontal canal - measures otolith function

• Records activity from the sternomastoid muscle in the neck in response to otolith response to intense auditory stimuli

• Useful for identifying SSCD
Management of vestibular disorders:

- Dietary changes/ migraine prophylactics in BPV
- Vestibular rehabilitation therapy – children typically more plasticity- compensate well for deficits
Vestibular Rehabilitation

- CawthorneCooksey,
- Tailored individual exercises
- WiFit- balance games
- Specialised physiotherapy
Take home messages

- Vertigo/ dizziness in children should always be investigated

- Importance of child-centred approach- involve child in history, etc

- Essential to get rapport of child for testing - Make it fun!

- Vestibular rehabilitation is easier in children, so worth it!