Because concussions will never be fully preventable, recognizing and providing appropriate care for concussive injuries is crucial.

-Guskiewicz et al., 2014

Module Overview

- On-field/sideline management
- In-office evaluation
  - History (Mechanism, LOC?, Red-Flags)
  - Physical Exam
    - Neurological Exam: C.N. Cerebellum, Upper & Lower Limb
    - Vestibular-Oculomotor Screen (VOMS)
    - Repeat Baseline (if necessary)
  - Education
- Utilizing the CCMI database for injury assessment
Observable Signs

- Lying motionless on playing surface
- Balance/gait difficulties/motor incoordination: stumbling, slow/laboured movements
- Disorientation or confusion, or an inability to respond appropriately to questions
- Blank or vacant look
- Facial injury after head trauma

International consensus definition of video signs of concussion in professional sports

- The use of video technology or ‘concussion spotters’ has rapidly grown in professional sports
- Objective was to develop a consensus for the signs considered the most useful in identifying possible sport-related concussion
- Senior medical advisors and chief medical officers from major professional sporting organizations participated in the study
  - They were presented with a list of 17 different video signs of possible concussion and completed a brief questionnaire that identified the most important signs of concussion
- A consensus was identified if a sign had >90% agreement among respondents

Results

- The following 6 video signs reached >90% agreement for possible concussion:
  1. Lying motionless
  2. Motor incoordination/ataxia/staggering gait/stumbles/stagger
  3. No protective action—floppy
  4. No protective action—tonic
  5. Cervical hypotonia
  6. Impact seizure/convulsion
  7. Tonic posturing
  8. Blank/vacant stare

Consensus video signs of possible concussion
Suspected Concussion - On field

- Athlete down on field
  1. Stabilize the neck & instruct not to move
  2. “What is your name?” (1st question always)
     - If unresponsive, check ABC’s & proceed accordingly
  3. If responsive, ask the following questions (orientation/maddox questions)
     - Where are you? What day is it? What is the score?
     - When was our last game? What was the score?
     - Tell me what happened! (Amnesia of event)
  4. What are you feeling? (symptoms - provide examples)
     - HA, Dizziness, Nausea, Ringing in ears, blurry?

On-field

5. Do you have any pain in your neck?
   - check for spinous tenderness
6. Do you have any pain in your arms/legs?
7. Assess sensory of extremities while stabilizing the neck
8. Assess active movement of extremities
9. Have athlete rotate neck side to side - must be able to turn head >45° each direction w/o pain

Suspected Concussion - Sidelines

- If athlete comes off under own power, but you are suspecting concussion
- Sit them down immediately
- Maddock’s questions (Tailor to sport) - /5
  - Where are we today? (venue)
  - What period/half is now?
  - Who scored last in this match?
  - What team did we play last week/game?
  - Did your team win the last game?
Sidelines Cont’d

- Ask about symptoms
  - If no symptoms, ok to continue
  - If ANY symptoms, pull from the game
- No medications
- Neuro Exam (Cranial Nerve screen & Cerebellar Testing)
- Look for signs of skull fracture
- SCAT5 (CCMI Concussion Tracker App)
- Remove gear and sit in shade – body temp has shown to sig glutamate release in animals, thereby lessening neuro dysfunction (Miyauchi, 2013; Seuhiro, 1999; Sakurai, 2012)
  - body temp following TBI is associated with glutamate excitotoxicity
  - Also increased inflammatory response, more severe and longer lasting consequences of TBI (Miyauchi et al., 2011)

Removal from play & recovery time

Eklek et al., 2016

Immediate Removal From Activity After Sport-Related Concussion Is Associated With Shorter Clinical Recovery and Less Severe Symptoms in Collegiate Student-Athletes

Asken et al., 2018

Immediate Removal From Activity After Sport-Related Concussion Is Associated With Shorter Clinical Recovery and Less Severe Symptoms in Collegiate Student-Athletes

- Ask about symptoms
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  - body temp following TBI is associated with glutamate excitotoxicity
  - Also increased inflammatory response, more severe and longer lasting consequences of mTBI in mice (Miyauchi et al., 2011)

Eklek et al., 2016

Immediate Removal From Activity After Sport-Related Concussion Is Associated With Shorter Clinical Recovery and Less Severe Symptoms in Collegiate Student-Athletes

- Asken et al., 2018

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Preliminary evidence of a dose-response for continuing to play on recovery time after concussion

- Data from 130 athletes (age 11-19) who sustained a sport-related concussion were reviewed.
- Athletes presented to a specialty concussion clinic within 7 days of injury. During the first visit, athletes or guardians completed an intake form, clinical interview and ImPACT (which includes PCSS), specifically asking when they recall sustaining their concussion and how long they continued to play before being removed: immediate removal, continued to play for 15 minutes or less (short play) or continued to play for 15 minutes or longer (long play).
- Athletes were re-assessed at 8 to 30 days post-injury to determine recovery and re-administered ImPACT.
- Recovery time was the number of days from date of injury to clearance.
- 52 athletes were removed immediately following concussion injury, 24 athletes continued to play for less than 15 minutes after injury and 32 athletes continued to play for 15 or more minutes following injury.
- Days from injury to clearance were as follows:
  - Immediate removal group: 18.98 days (27% of athletes had protracted recovery >20 days)
  - Short play group: 24 days (67% of athletes had protracted recovery)
  - Long play group: 44.09 days (81% of athletes had protracted recovery)
- Athletes in the short play group were 5.43 times and long group were 11.76 times more likely to experience a protracted recovery compared to immediate removal group.

Monitor for 2-3 hours

- Do not allow athlete to sleep for at least 3 hours after concussion
  - Want to monitor for decreasing condition
  - Intracranial hemorrhage/edema
  - Will likely be very fatigued (ATP decline)
  - Keep Canadian CT head rules and New Orleans Criteria in mind for monitoring period
- No longer need to wake up throughout first night
  - Should be checked on and woken if concerned about breathing or state
- Athlete should be in to trained HCP ASAP
  - CCMI Data = First 5 days is highly predictive of a faster recovery

Neurocognitive Patterns, Symptom Clusters, and Prenoid Factors that Predict Protracted Recovery from Concussion in Females

Palaski 2019 – PhD Thesis
Mild traumatic brain injury in New Zealand: factors influencing post-concussion symptom recovery time in a specialised concussion service

Forrest et al., 2018

Red Flags - Hemorrhage/IP

- Severe or worsening HA
- Seizures (w/ no history of seizures)
- Weakness in an extremity
- Nausea/Vomiting
- Decreasing alertness
- Changes in vision
- Tingling or numbness
- Difficulty speaking or understanding speech
- Difficulty swallowing
- Difficulty writing or reading
- Loss of fine motor skills - Tremors
- Loss of coordination
- Loss of balance
- Abnormal sense of taste
- LOC

Refer to ER!
For parents/coaches

- If you have any of the following, or if you are unsure at all, please visit the ER! (Imaging)
  - Severe or worsening headache
  - Very drowsy or can’t be awakened
  - Seizures
  - Decreasing level of consciousness >2hrs after injury (can’t recognize ppl or places)
  - Unusual behavior, very confused, very irritable
  - Weakness or numbness in arms or legs
  - Unsteady on feet or have slurring of speech
  - Fluid leaking from ears, bruising behind ears, 2 black eyes
  - Vomiting
  - Inability to remember more than 30 minutes before the injury

Clinical Assessment

- Examination should encompass:
  - Comprehensive history and detailed neurological exam including a thorough assessment of mental status, cognitive functioning, sleep/wake disturbance, ocular function, vestibular function, gait and balance
  - Determine whether there has been improvement or deterioration since the time of injury
    - May require seeking additional info from parents, coaches, teammates etc.
  - Determine the need for emergent neuroimaging to exclude a more severe brain injury

In office assessment

- Should see you w/in 24 to 48 hours (Important)

  Point of Initial Assessment: Rule out more serious Injury! THAT’S IT!

- Initial assessment:
  - History of concussion
    - Symptoms at time of impact, LOC, vomiting, etc.
    - If they had ANY symptoms following the impact = concussion!
    - Have they been getting better or worse since the injury?
  - Symptoms you feel right now (PCSS = 22 symptoms)
    - To give us a starting point for the recovery
    - mTBI performs no differently than orthopedic injuries in immediate setting on cognitive measures (Brown et al., 2016; Nelson et al., 2017) compared to normative data on neurocognitive scores (Brown et al., 2016; Nelson et al., 2017)
Comparing the acute presentation of sport-related concussion in the pediatric and adult populations

This retrospective cross-sectional study looked to compare injury characteristics, symptoms, and neuro exam findings in acute sport-related concussion between pediatric and adult populations.

Patients visiting an outpatient sports neurology clinic for concussion assessment had their medical charts extracted for review.

- 155 patient charts were included for review and divided into 2 groups: all patients were seen for assessment within 7 days of injury.
  - Group 1: 28 patients, 18-74 years of age
  - Group 2: 107 patients, 18 years of age or younger

All patients underwent a complete neurological exam along with SCAT 3 symptom scale.

Results:
- Median age of group 1 was 23 years of age and median age for group 2 was 15.1 years of age.
- Group 2 reported significantly more hours per night of sleep in comparison to group 1, but following the injury significantly fewer patients in group 2 reported waking up refreshed.
- There was no difference between the age groups in prevalence of pertinent past medical history, SCAT 3 symptom scores or neurological findings.

Authors conclusions: “There does not appear to be an indication for focusing on specific portions of the history vs. neuroexam examination based on whether the patient is above or below the age of 18. Initial presentation of acute concussion within 7 days of injury will likely not differ by age.”

SCAT for diagnosis in ED

- N=262 (87 head injury CT negative, 31 head injury CT positive, 46 orthopedic body injury, 98 healthy nonathletes)
- Administered Glasgow Coma Scale (GCS), Symptom Checklist (SC) and Standardized Assessment of Cognition (SAC) from SCAT
- Developed a decision tree for the predictability of SCAT 3 in diagnosing concussion in the ED

Results: Clinical Predictability for a concussion vs. orthopedic injury:
- Symptom Severity Score of >7 AND headache or pressure in the head OR
- Symptom Severity Score <7 AND an SAC score of <22

NOTE: patients with orthopedic injuries were also coming in with high symptom severity scores (average = 19.4, SD = 18.5 for orthopedic vs. CT negative = 41, SD = 28.2 vs. CT positive = 42.3, SD = 29.6) but the one differentiating feature between head injury and orthopedic injury was having a headache.

Do I do a Baseline Re-test (i.e., Post-Injury Test)?

- Yes? Do a Post-Injury Test!
- No? Do a Prolonged Post-Injury Test
- Unsure? Treat it like a concussion

Elbin et al., 2018
Do I need any fancy tools or tests?

- Imaging?
  - MRI/CT
  - Diffusion Tensor fMRI?
- EEG testing/Neuroelectrophysiological testing?
- Video-oculography?
- Pupilometry

Prevalence of potentially clinically significant MRI findings in athlete with and without sport-related concussion

- The goal of the study was to characterize and compare the prevalence of acute, trauma related MRI findings and clinically significant MRI findings in athletes with and without sport-related concussion.
- Additionally, to assess whether athletes from across Wisconsin were enrolled in the study and underwent MRI imaging.
- The athletes were divided into 3 groups:
  1. 138 athletes sustained a diagnosed concussion during their football season.
  2. 135 football players who did not sustain a concussion.
  3. 96 non-contact control athletes.
- Athletes who sustained a concussion underwent MRI within 24-48 hours post-injury, following clearance to begin RTP progression (symptoms), 7 days following unrestricted RTP, and 6 months post-injury.
- Contact and non-contact control athletes underwent MRI imaging at similar time points to the concussion group.
- For the purpose of the study, MRI abnormality was defined as any acute (injury related) or non-acute finding that promoted recommendation for clinical follow-up.

Authors conclusion:

"This prospective, large-scale study demonstrated that <1% of sport-related concussions are associated with acute injury findings on qualitative structural MRI, providing empirical support for clinical guidelines that do not recommend use of MRI following sport-related concussion."
Electrophysiological testing in concussion: a guide to clinical applications

• This article reviewed the existing literature on electrophysiological testing in concussion and mTBI. We have briefly described each testing method with overall conclusion of the existing literature.

Electroencephalogram (EEG)
• An EEG test is used to evaluate electrical activity of the brain by placing electrodes on the head and observing the responses to various stimuli.

Visual evoked potential (VEP) – Visual system
• A VEP is caused by a visual stimulus and responses are recorded from electrodes that are placed on the back of the head and are observed as a reading on an electroencephalogram (EEG).

Brainstem auditory evoked potential (BAEP) – Auditory system
• BAEP test records your brainwaves in response to clicks or other audio tones that are played. Electrodes positioned on the head record responses to sound and these are observed as a reading on an EEG.

Transcranial magnetic stimulation (TMS)
• TMS creates a magnetic field to induce small electric currents in a specific part of the brain. The current is caused by the magnetic field created by an electromagnetic coil. In mTBI it is used to generate cortically mediated muscle responses (myogenic potential) in target muscles to determine its excitation, or lack there of.

Somatosensory evoked potentials (SEP)
• A stimulating electrode is placed on the arm or leg and it generates an electrical signal where recordings from electrodes placed on the head and spine are observed.

Polysomnography (PSG) – sleep
• PSG utilizes a variety of monitoring devices to record a person’s brain waves, leg movements, heart rate, oxygen level and breathing rate during sleep.
Electrophysiological testing in concussion: a guide to clinical applications

Conclusion on electrophysiological testing in concussions

Electroencephalography (EEG) is also found to be impacted by physical exertion alone [Devillers et al., 2019].

There are a number of commercial devices being sold and marketed as sideline diagnostic tools, however there are still many challenges with this! And the challenges are with 128-lead systems – these commercial units are never more than a handful of leads.

Initial visit con’t

- They have a concussion
  - Now to rule out more sinister pathology (DO THEY NEED A CT SCAN?) – RED FLAGS
    - Cerebral swelling, focal neuro damage, skull/neck fracture
    - Anticoagulant/Antiplatelet medications! (Uccella et al., 2017 – increased risk of bleeding even with a full GCS and no Red Flags)
- Cranial Nerve exam
- Cerebellar Testing (Include BESS – Zemek study)
- Upper & Lower limb neuro
- Patient education & reassurance!!!
  - One of the best ways to ↓ the risk of persistent symptoms

Red Flags - Urgent Referral!

New Orleans Criteria
- CT is required for pts w/ minor head injury w/ any 1 of the following findings. The criteria apply to GCS score of 15
  - Headache
  - Vomiting
  - Older than 60yrs**
  - Drug or alcohol intoxication
  - Persistent antegrade amnesia
  - Visible trauma above the clavicle
  - Seizure

Canadian CT Head Rule *
- CT is only required for patients with minor head injury who present a GCS of 13-15 after witnessed LOC, amnesia, or confusion
  - GCS lower than 15 @ 2 hours**
  - Suspected skull fracture
  - Any sign of basal skull fracture
  - 2+ episodes of vomiting
  - 65 or older**
  - Amnesia before impact of 30 or more minutes
  - Dangerous mechanism

* = found to be superior (Mata-Mbemba et al., 2016)
** = The strongest predictor of positive CT findings (SAA)
Skull Fractures – what to look for

Diagnostic features
- Open fracture
- Palpable discrepancy in bone contour
- Postauricular ecchymosis (Battle sign - bruising around the mastoid)
- Periorbital ecchymosis (Racoon eye(s))
- Bloody ear discharge
- CSF drainage from the nose
- Facial paralysis, nystagmus, paresthesia, abnormal pupillary reflex
- Vomiting
- Altered mental state

Clarification

- Signs of skull fracture
  - Hemotympanum, raccoon eyes, CSF (otorrhea or rhinorrhea), battle’s sign
- Dangerous mechanism
  - Pedestrian struck by vehicle, occupant ejected from vehicle, or fall from an elevation of 3 or more feet, or 5 stairs

Pediatrics

- The PECARN (USA) is currently the best (highest sensitivity vs. other pediatric rules – Bald et al. 2017)
  - Pediatric Emergency Care Research Network
- Broken up into under 2 years old and between 2 and 18
- Nakhjavani-Shahraki et al., 2017 (n=594 children)
  - PECARN had a sensitivity of 92.3% and specificity of 40.6% in predicting clinically important injury in children under 2 years of age.
  - PECARN had a sensitivity of 100.0% and specificity of 57.8% in predicting clinically important injury in children between 2-18 years old.
Rule out C-Spine Injuries!
(fx & artery dissection)

Canadian C-Spine Rule
Excluding cervical artery dissection

Neck pain and Cervical Artery Dissection

- Coexisting CAD with neck pain presents as sudden, sharp, severe, steady and different from previous episodes of neck pain.
- CAD neck pain may present at throbbing, pounding, pulsing, and/or beating while MSK neck pain is usually aching, sore, heavy, hurting, deep, cramping, and dull.
  - Neck pain is graded from I - IV. Grade III and IV neck pain warrant awareness for possible CAD.
- MSK neck pain is often reproducible and can be provoked by active or passive movements and relieved by certain movements, which is not the case if the pain is vascular in origin.
- Vascular pain is not typically relieved by analgesics.
- Mechanical neck pain appears to present in the lower cervical spine with vascular pain being around occipital region and medially along nuchal line.
- Common symptoms such as neck pain, stiffness, tenderness without a change in response to mechanical provocation maneuvers, clinicians should be alerted to possible red flags.

VA and ICA anatomy and typical pain distributions during dissection

Horner syndrome – classic triad of constricted pupil, partial ptosis (dropping of upper eyelid) and loss of hemifacial sweating (anhidrosis).

Retinal ischemic symptoms – e.g., vision loss

Brainstem ischemic symptoms – difficulty breathing, difficulty swallowing, dysphagia, dysarthria, partial/complete hearing loss, blurred vision, weakness in limbs, paralysis, numbness or loss of sensation.

Cerebellar ischemia symptoms – uncoordinated movement of limbs or trunk, difficulty walking (problem with balance), abnormal reflexes, tremors, vertigo, nausea/vomiting, intense headache.

A step-by-step risk benefit strategy to exclude CAD

Paper included below!

Chaibi et al. 2019
History of Life-Threatening TBI

- Epidural Hematoma (EDH) & Subdural Hematoma (SDH)
  - In the absence of underlying coagulopathy or brain lesion (aneurysm or arteriovenous malformation) there is no thought of increased risk of repeat hemorrhage or concussion following EDH or SDH
- Subarachnoid Hemorrhage
  - Should not return to contact sports – RETIRE
- Second Impact Syndrome
  - A history of second impact syndrome causing near death is an absolute contraindication to returning to contact sports – RETIRE

Ultimately all clearance decisions for the above conditions should be made by a NEUROSURGEON

---

Cranial Nerve Exam

- CN I – Olfactory – Smell
  - Does not cross midline – unilateral anosmia = cortical lesion on same side
  - “Have you noticed any changes in smell or taste?”
  - Also covers a bit of facial nerve (ant 2/3 of tongue) and glossopharyngeal (post 1/3)
  - If yes, test

- CN II – Optic
  - Visual Acuity & Gross Visual fields
    - Snellen Chart (Pocket or Wall)
    - Lowest line they can read with each eye
    - Peripheral Vision (confrontation)
      - Pt. covers 1 eye and looks directly at your nose
      - Wiggle both index fingers in the periphery and ask “which finger is wiggling?” – they should say both
      - Repeat for superior and inferior visual fields
    - Decline in acuity following mTBI should be referred to ophthalmologist
**CN III, Oculomotor (pupils)**

- Pupillary reaction to light (PERRLA)
  - It is a common sign for one pupil to be dilated compared to the other immediately after a concussion (anisocoria)
  - Dilated pupil is typically on the side of impact
  - Should resolve within 1-2 hrs - if not ER! (intracranial pressure)
  - It is also common for the pupil on the side of injury to not react to light for a brief period of time after concussion
  - If the pupil is still dilated and/or not reacting to light 2 hours after injury - ER!
  - Both of these findings are related to a sympathetic response following concussion
  - If the dilated pupil is due to an actual lesion within the brainstem, there is likely to be other findings as well

**PERRLA – Acronym**

- Pupils
- Equal
- Round
- Reactive to:
  - Light
  - Accomodation

**III, IV, VI**

- H- Pattern
  - Hold at extremes
  - If patient reports diplopia with a certain position, make note of that position
    - Then block one eye - in true diplopia, the diplopia will disappear
    - If not, could be a detached retina (unilateral diplopia)
  - Looking for nystagmus
    - Slight nystagmus is normal
    - Jerk Nystagmus - A fast & slow component
    - Nystagmus usually involves the labyrinthine apparatus (vestibular problem)
Visual Tracking – Smooth Pursuit

• More on this when we discuss PCS
  – Smooth Pursuit - During H- Pattern, have the athlete track your finger back and forth to make sure they are tracking properly
  – Also ask them how this makes them feel
    • Some report dizziness, headaches, or blurred vision
    • This finding is non-specific but may end up being one of the causes of lingering dizziness and headaches
      – Retest this throughout recovery to see if there is improvement
    – More on this with VOMS assessment
      – https://www.youtube.com/watch?v=gqCgqSSwPlk

Convergence & Accommodation

• Common dysfunctions after concussion
• Need a convergence ruler and 14-point font
• Convergence
  – Test binocularly
    • Bring convergence rule gradually closer to the individual and ask them to report when they begin to see double (normal = <5cm)
    • Greater than 5 = convergence insufficiency
• Accommodation
  – Test unilaterally and cover opposite eye
    • Bring convergence rule gradually closer and ask them to report when it gets blurry (should be wearing normal corrective eyewear (normal = < 11cm))
Convergence insufficiency identifies athletes at risk of prolonged recovery

Normal NPC = <5cm
Convergence insufficiency = >5 cm

This is measured at the point when the patient sees double or you observe outward deviation of the eyes.

Figure 1 Demonstration of the near point convergence test.

CN V (Trigeminal)

- Facial sensation
  - A CNS lesion that compromises CNS will involve the entire nerve – so really only need to test 1 branch
- Motor to muscles of mastication
- Corneal reflex
  - CNS is sensation, CN7 is motor
  - Only really need to test this to confirm a CNS lesion
CN VII - Facial

- Motor to facial expression
  - Key test is having them smile
  - Look for flattening of nasolabial fold
  - Typically this will be evident without having to test it
  - Raise the eyebrows

Cn VIII - Vestibulocochlear

- Hearing & balance
  - Key test: Can they hear your fingertips moving
    - Rub your fingers together on one side of the patient and ask them to point to the side they hear it on
    - If there is a defect, then try to determine whether it is conductive or sensorineural
    - Tuning fork - Webers & Rinne test or...
    - Humming - ask the patient to hum
      - Conductive loss - hum is heard louder in the ear that had the defect during the finger test
      - Sensorineural loss - hum is heard louder in the ear that could hear the fingertips better (loss is on the side that could not hear the fingertips rubbing together)

CN IX & X

- Key test: Gag reflex
  - Depress tongue with tongue blade & touch soft palate
  - Look for gag response and raising of uvula symmetrically
  - One sided injury = palate will retract towards the normal side (away from damaged side)
  - Can also have patient say ‘AH’ and then swallow
  - Recurrent laryngeal nerve (vagus) damage will also result in hoarseness of the voice
**CN XI & XII**

- **CN XI - Spinal Accessory**
  - Key Test: Resisted Shoulder Elevation
  - Can also test SCM via resisted cervical rotation
  - Unnecessary unless there is a problem with shoulder elevation
- **CN XII - Hypoglossal**
  - Key test: Stick out tongue
  - If problem - tongue deviates towards the side of the lesion
  - Both of these nerves are very rarely affected
- Be sure to watch CN screen video!!

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**Pronator Drift**

- Assesses for pyramidal tract lesion
  - Standing or seated, eyes closed, shoulders flexed to 90°, palms up
  - 20-30 seconds – looking for hand/arm to pronate and/or drop
  - Contralateral pyramidal lesion (UMNL)
    - May be very subtle
  - Can also indicate a hemorrhage
  - Can accentuate response by perturbing the patient's hand downwards
  - If patient overshoots or drifts upwards, this indicates a cerebellar lesion

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**Cerebellar Testing**

- Cerebellar injuries are rare in concussion
- Romberg's (more proprioceptive than cerebellar)
  - Eyes open, then eyes closed
  - Can do BESS protocol here and/or put on force plate
- Tandem gait (forwards and backwards)
  - Assessing coordination and balance
- Finger to nose (SCAT3)
- Heel to shin
- Rapid Alternating Movements
  - Dysdiadochokinesis
- Video
Upper & LL neuro

- DTR
- Sensory
  - Light touch
  - Pain
  - Proprio (joint position sense)
- Motor
- Pathological Reflexes
  - Plantar Response
  - Hoffman’s

Abnormalities?

- Refer Immediately - ER
- To rule out sinister pathology (CT Scan)
  - Write a quick note explaining why you have sent them - hopefully get them in faster

Do I do a Baseline Re-test (i.e., Post-Injury Test)?

- Did they have a clear mechanism of injury and ANY immediate symptoms?
  - Yes?
    - Do a Post-Injury Test!
    - Do not do Post-Injury Test!
  - No?
    - NO Post-Injury Test Required
    - CAN do a VOMS though!
      - 2pt ↑ = likely concussion

- Unsure
  - err on the side of caution! Treat it like a concussion
  - err on the side of caution! Treat it like a concussion
**Vestibular-Oculomotor Screen (VOMS)**

- Developed to assess vestibular and ocular motor impairments via patient-reported symptom provocation after each assessment.
  - Consists of the following 5 domains:
    - Smooth Pursuits (0-10)
    - Horizontal and Vertical Saccades (0-10)
    - Horizontal Vestibular Ocular Reflex (VOR) (0-10)
    - Visual Motion Sensitivity (0-10)
    - Convergence (0-10) & Accommodation (0-10)
  - Take baseline symptoms (Headache, Dizziness, Nausea, Fogginess)
  - Ask about same symptoms after each test
  - You are looking for a provocation of symptoms > 2-point increase in any symptom from baseline is considered significant – confirmed by Elbin et al., 2018.
  - Can help to point out vestibular/oculomotor dysfunction and help guide rehab and potentially academic accommodations.
  - Be sure to follow along as we go with the VOMS video below!

**VOMS Testing/Scoring**

<table>
<thead>
<tr>
<th>Vestibular/Ocular Test</th>
<th>Headache (0-10)</th>
<th>Dizziness (0-10)</th>
<th>Nausea (0-10)</th>
<th>Fogginess (0-10)</th>
<th>Comments</th>
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<tbody>
<tr>
<td>Pre-Test Symptoms</td>
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<tr>
<td>Smooth Pursuits</td>
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<td>Saccades - Horizontal</td>
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<td>VOR - Horizontal</td>
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<td>VOR - Vertical</td>
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<tr>
<td>Visual Motion Sensitivity Test</td>
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<tr>
<td>Accommodation (Right)</td>
<td>Distance: ____cm</td>
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<tr>
<td>Accommodation (Left)</td>
<td>Distance: ____cm</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Convergence</td>
<td>Near Point:</td>
<td></td>
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</tbody>
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VOMS Administration

• Smooth Pursuits
  - Patient and examiner seated 3 ft apart
  - Examiner moves their finger 1.5 feet to the right, then back to midline, then 1.5 feet to the left in a smooth motion - should take 2 seconds to complete
  - Repeat 2 times and then do the same thing vertically (1.5 feet above midline to 1.5 feet below midline)
  - Ask patient to rate headache, dizziness, nausea, and fogginess from 0-10

VOMS Administration

• Horizontal Saccades
  - Same distance as previous test (3ft)
  - Examiners fingertips are held 3 feet apart (1.5 feet from midline in either direction)
  - Patient is instructed to look side to side for a total of 10 reps (head stays still, only eyes move)
  - Ask patient to rate headache, dizziness, nausea, and fogginess each out of 10
  - Also make sure that eyes are able to lock on to the target in 1 or 2 eye movements and that both eyes are moving together

• Vertical Saccades
  - Same as above but fingers are held 1.5 feet above and 1.5 feet below patient's midline
  - Ask patient to rate each symptom

VOMS Administration

• Horizontal VOR (vestibular ocular reflex)
  - Examiner holds a sheet of paper with the letter 'A' on it at midline, 3 feet from the patient (we use checkerboard)
  - Patient moves their head back and forth 20 degrees to each side while fixing their eyes on the target
  - 10 reps @ 180Hz (beats per min) metronome pace (can download free metronome apps for your phone!!)
  - Ask patient to rate headache, dizziness, nausea and fogginess each out of 10

• Vertical VOR
  - Same as above but the patient moves their head up and down 20 degrees from midline in alternating fashion at the same 180Hz frequency
  - Ask patient to rate symptoms out of 10
VOMS Administration

• Visual Motion Sensitivity
  - Patient stands – examiner stands just behind and to the side of the patient to allow free motion of the patient – Examiner to act as a ‘spotter’ in case the patient loses balance
  - Patient extends their arm with their thumb up
  - Patient moves their trunk, head, and eyes as one unit while their eyes stay fixated on their thumb, rotating 80 degrees to the right and 80 degrees to the left.
  - 10 reps @ 50Hz (beats per minute) – get a metronome app
  - Ask patient to rate headache, dizziness, nausea, and fogginess from 0 - 10

• Accommodation
  - Patient seated
  - Each eye is measured independently
  - Using a convergence rule and a piece of paper with 14 point font, patient covers one eye and brings the paper towards their face until they report blurriness
  - Examiner measures the distance from the patient’s forehead (normal is within 10cm – this distance increases with normal ageing)
  - Assess for HA, dizziness, nausea, fogginess
  - Repeat with other eye

• Convergence:
  - Seated
  - Both eyes tested together - Target again is 14 point font (or a single vertical line) on a convergence rule - patient holds paper and brings it closer to their face until they see double
  - Examiner measures distance (normal is 5 or less cm)
  - Assess HA, dizziness, nausea, fogginess
Other tests to include

• Orthostatic Vital Signs
  - Autonomic dysregulation is common after a head injury and may present with symptoms of orthostatic hypotension (OH), dizziness or vestibular dysfunction, postural orthostatic tachycardia syndrome, or altered HR and blood pressure (BP) responses at rest and during exercise. — Adler et al., 2018
  - Orthostatic hypotension
    - A reduction in systolic BP of 20 mm Hg or a 10 mm Hg reduction in diastolic BP after 1 and 3 minutes of standing from the supine position.
    - Because the prevalence of OH is between 5% and 30% in the non-concussed population, this change in BP is not clinically significant unless accompanied by symptoms of dizziness or lightheadedness. — Haider et al., 2018
    - Heart rate response is useful because a rise in HR (40 beats per minute standing vs supine) with a drop in BP usually indicates hypovolemia, whereas lack of HR response is more consistent with a central neurogenic cause.
    - Patients with symptoms of dizziness or vertigo while supine are more likely to have a peripheral vestibular injury and testing including the Dix–Hallpike maneuver or otoscopic examination may be indicated.
    - Orthostatic vital signs are measured only supine to standing because two-thirds of cases can be missed seated to standing.
  - Postural Orthostatic Tachycardia Syndrome (POTS)

• BESS
  - Some evidence that having >4 errors on Tandem gait may be predictive of prolonged recovery (Zemek et al., 2016; Leddy et al., 2018; Howell et al., 2018)

Concussion Diagnosis?

• No RED FLAGS?
• Proceed with concussion management
  - Education! — Help them to download and sign in to app as well
  - Return to Learn
  - Return to Play
  - Final clearance

POTS

- A form of dysautonomia (disorder of the autonomic nervous system) characterized by sustained tachycardia (heart rate >100 beats/min) that occurs upon standing.
- 3 clinical subtypes of POTS:
  1. Hypovolemic — Regulatory mechanisms for plasma volume do not work properly impairing water and sodium retention leading to reduced total blood volume.
  2. Neuropathic — Partial sympathetic denervation of blood vessels in the lower extremity resulting in reduced vasoconstriction during upright posture. This impaired venous return pools blood in the abdomen and lower limb, which results in compensatory tachycardia and reduced exercise capacity.
  3. Hyperadrenergic — Development of excessive plasma norepinephrine upon standing leading to profound sympathetic activity.
- Prevalence: 1-3 million Americans — typically occurs in adolescent girls and women of childbearing age
- Symptoms: dizziness, lightheadedness upon standing, vertigo, headache, nausea, reduced mental clarity, “swimming” or “rocking” sensation, and generalized fatigue (all very similar to concussion symptoms)
- A retrospective study of 722 patients with POTS with 11% demonstrating a temporal link to a concussive event, which adds to the potential of POTS being triggered by head trauma and rapid deceleration injuries.
- Patients should be referred back to primary care physician for further investigation
- Initial management involves increasing fluid intake and sodium consumption, wearing compression stockings to encourage peripheral vasoconstriction, and pharmacological support
- Progressive exercise training also has some supportive research
- More on the treatment when we cover persistent concussion symptoms as this is more likely when you’d see it!
Prognosis?

- **5P Study** – “Predicting and Preventing Postconcussive Problems in Pediatrics”
- 9 different pediatric emergency departments across Canada
  - Inclusion: patients between 5 & 17 yrs old who presented to 1 of the 9 ER’s within 48 hours
- **Study Design:**
  - Prospective Cohort
  - Primary Outcome - ICD-10 criteria for PCS (3+ symptoms at 4-weeks)
  - Examined a number of variables at initial evaluation to develop prediction rule of who would go on to PCS

**5P PPCS Risk Score Criteria**

<table>
<thead>
<tr>
<th>Score</th>
<th>Description</th>
</tr>
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<tbody>
<tr>
<td>&lt; 3</td>
<td>Low Risk</td>
</tr>
<tr>
<td>4 – 8</td>
<td>Medium Risk</td>
</tr>
<tr>
<td>&gt; 9</td>
<td>High Risk</td>
</tr>
</tbody>
</table>

*Zemek et al., 2016*

  - Applied this prediction rule
  - 58% went on to have PCS!
  - Those that scored 5 points or higher had a greater likelihood of experiencing persistent symptoms
  - Fatigue & >4 errors on tandem stance were most associated

**Derivation of a focused, brief concussion physical examination for adolescents with sport-related concussion**

- 52 acutely concussed adolescents (mean of 15.5 years old and 4.4 days post injury) were compared to 30 non-injured age matched controls.
- At initial visit (visit 1), the following physical examination findings successfully distinguished concussed from healthy participants:
  - Cervical tenderness, abnormal smooth pursuits, abnormal near point convergence, abnormal horizontal saccades, abnormal vestibulocular reflex, and abnormal tandem gait
- At visit 2 (avg 13.6 days after initial), 41/52 acutely concussed athletes had a normal recovery (meaning they had recovered by visit 2), whereas 11/52 had delayed recovery (ongoing symptoms at visit 2)
  - The following abnormal physical examination findings were found in the delayed recovery group: abnormal smooth pursuits, abnormal near-point-convergence and abnormal tandem gait
Factors associated with persistent post-concussion symptoms following mTBI in adults

- 342 concussed adults (>18 yoa) were seen in the ER and completed 4-week follow-up.
- The presence of pre-morbid psychological issues significantly predicted persistent concussion symptoms. This has been confirmed in multiple studies.
  - Participants reported 2.99 times per PCS if they had pre-morbid psych issues.
- The presence of LOC significantly predicted persistent concussion symptoms. Previous studies indicate LOC is not associated with persistent symptoms.
  - Participants reported 2.47 times more symptoms if they experienced a LOC.
- Participants who did not receive injury information at ER discharge significantly predicted persistent concussion symptoms.
  - Participants who did not receive injury info after discharge reported 2.34 times per symptoms than those who did not recall receiving information.
- EDUCATION!

Patient Education!
Get good at this!

Patient App
- At the bottom of the assessment form, there is an option to send them an email about the app!
  - Sends to the email address on file, includes:
    • Concussion Information Package
    • Return-to-Learn/Work & Return-to-Play stages
    • App also links with your SOAP notes - whatever stage you put them in, they will be able to see specific instructions for that stage - i.e., academic & athletic restrictions
    • Concussion Recovery Diet
    • Daily Symptom Updates - They input their symptoms on their app every day - this goes right to their file on your system!
  - Working on ability to send specific rehab exercises!
Recovery Dashboard
Give patients the best chance for a speedy recovery!

Patient's Personal Dashboard
- View recovery timeline
- Specific information provided at each stage of recovery
- Track symptoms
- Send progress updates
- View recovery diet plans
- Access recovery tips
- Communicate with treating healthcare providers

Symptom Tracking
Flexible platform enables players and coaches to send symptom updates to treating healthcare providers.

Watch ALL Videos Below
(VOMS, Neuro Exams, Patient Education, Database Operations, Etc.)