Concussion Assessment: What, When, Who

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• Rationale
• The overall process/stages
• Review of tests at different stages
• Why is assessment important
  – You know it when you see it
  – Do we? No biomarker
  – Cancer
• The need for standardized tools and procedures
• ‘Clinical trials quality data’: not just for research, but communication
EVALUATION, ASSESSMENT & TESTING

Although definitions overlap...evaluation & assessment often interchanged

• #1: Testing is NOT assessment

• Assessment is the process of gathering data in a systematic manner in order to make a judgment or decision;

• Evaluation is the ‘deciding’ based on the evidence from the assessment.

Diagnosis & Assessment Timeline

- **24 hr**
  - Diagnosis
  - Within 48 hrs

- **48 hr**
  - Post-Injury Assessment
  - 24-48 hrs
  - As needed – Often after 7-10 days if still symptomatic

- **7-14+ days**
  - Serial Assessment
  - When a-sx
  - If not recovered in 2-4 weeks; more comprehensive, focused on symptoms

- **>2 wks**
  - Asymptomatic Assessment (Recovery)
  - Post-acute

Begin active rehab
Concussion assessments have several components

- Baseline
- Sideline
- Acute
  - Immediate: 2 days post
  - Post-Acute: 2 days-2 weeks post
    - Includes recovery
- Chronic
  - 1 month+ post

Baseline testing

- Why?
  - Theory: compare individual to themselves instead of a normative standard
- Is it necessary?
  - Not for a neuropsychologist
  - Useful if testing is reliable
  - Best for identifying those who are not in the average range
  - Costs in time and money are factors to consider
  - BUT is still considered important
- Other factors include sandbagging
- Effect of repeat
- Individual ‘state’ effects (sleep, mood, etc)
• In theory, the initial assessment is to determine continuation in play or not.
• Many concussions (50%?) are not identified on the field, but a day later.
• Diagnosis is a clinical decision

Recommended tools to aid in diagnosis

**SCAT3/5**

• Glasgow Coma Scale (GCS)
• Graded symptom checklist
• Orientation (Maddocks Q’s)
• Cognitive screening (SAC)
• Balance/BESS
• Neck exam
• Neuro exam
Immediate identification

• Berlin 17 noted that abbreviated testing paradigms are designed for rapid SRC screening on the sidelines and are not meant to replace a comprehensive neurological evaluation; nor should they be used as a standalone tool for the ongoing management of SRC.

• There is published support for using the SCAT and Child SCAT in the evaluation of SRC. The SCAT is useful immediately after injury in differentiating concussed from non-concussed athletes, but its utility appears to decrease significantly 3–5 days after injury.

We would state that SCAT utility decreases after 48 hours.

Changes to SCAT-5

Changes to SCAT-5

Changes to SCAT-5 (adult 13 and up)

• Declaration that the complete SCAT5 cannot be appropriately completed in less than 10 min.

• Affirmation that the SCAT5 was used or supervised by a healthcare professional and whether a concussion was diagnosed.

• The enhanced Instruction includes the modifications described above.

• Inclusion of an Immediate/Acute Assessment section, including indications for emergency management and observable signs of possible concussion.

• Clarified instructions that Symptom Checklist should be completed by the athlete in a resting state.

• Different instructions for completing the symptom checklist at baseline and post-injury have been added.
Changes to SAC

• Addition of questions that compare the athlete’s postinjury presentation with preinjury behaviour.
• The SAC immediate and delayed word recall lists include an option to use 10 words instead of 5 to minimise ceiling effects.
• All six versions of the SAC word lists are now presented with alternate stimulus sets for the word list and digits backwards. Their administration should be randomised at baseline and serially post-injury.
• A notation of when the last trial of the word list was administered is required (the delayed recall should not be administered sooner than 5 min after the immediate memory subtest).
• Digits Backwards now contains six versions of the digit strings, which should be randomised at baseline and serially postinjury.

Other changes

• A Rapid Neurological Screen has been included.
• The Return to Sport progression emphasises that the initial period of physical and cognitive rest should typically only last 24-48 hours.
• A Return to School progression has been added, including possible academic accommodations.
• The SCAT5 specifically indicates that written clearance by a healthcare professional is necessary prior to returning to play/sport.
• There is a child version (ages 5-12)
SCAT 3
GCS
Maddocks

Graded symptom Checklists

Graded: Likert scale of severity.
Compare symptoms before and after injury

May be used as part of the decision making process for RTP
SCAT 3 symptom ratings

Total number of symptoms (Maximum possible 22)
Symptom severity score (Maximum possible 132)

Do the symptoms get worse with physical activity?
Do the symptoms get worse with mental activity?

**Overall rating:** If you know the athlete well prior to the injury, how different is the athlete acting compared to his/her usual self?

Please circle one response:
- no different
- very different
- unsure
- N/A

Symptom Assessment: How do you count?

<table>
<thead>
<tr>
<th>Symptoms Scores</th>
<th>3/21/15</th>
<th>4/20/15</th>
</tr>
</thead>
<tbody>
<tr>
<td>Headache</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>Nausea</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>Vomiting</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Balance Problems</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>Dizziness</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Fatigue</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>Trouble falling asleep</td>
<td>1</td>
<td>N/A</td>
</tr>
<tr>
<td>Sleeping more than usual</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>Sleeping less than usual</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>Drowsiness</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Sensitivity to light</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>Sensitivity to noise</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>Irritability</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Sadness</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Nervousness</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Feeling more emotional</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Numbness or tingling</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Feeling slowed down</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Feeling mentally foggy</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Difficulty concentrating</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Difficulty remembering</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Visual problems</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Total Symptom Score</td>
<td>15</td>
<td>35</td>
</tr>
</tbody>
</table>

- DoI: 4/18/15
- BL Total = 15
- Post injury total 35 or 22?
- Number of post-injury symptoms 15 or 9?
Symptom Assessment is a \textit{criterion-referenced} assessment

- Many tests use the average score of a typical population (\textit{norm-referenced});
- In \textit{criterion-referenced} tests, the examiner must be confident that the respondent meets the criteria of the item.
- Impossible to know when self-administered.
- Does it matter?
  - College students who don’t know what “nausea”, “withdrawn”, or “fatigued” means
  - HS students who do not know what “headache” means

Cognitive screening

- Standardized Assessment of Concussion (SAC)
- Sensitive to diagnosis
- Baseline recommended
Acute Post-Injury assessment

- **Purpose:** to provide a post-injury assessment to compare to baseline;
- Confirm diagnosis;
- Help determine severity;
- Help with RTP decisions;
- Possibly to guide treatment;
- Ideally 48-20 hrs post-injury
  - Symptoms, Neuropsych, Vestibular, History (medical, behavioral);
- Symptoms more than what and how severe – changes from injury (course)
Symptom checking: how often?

- In serial monitoring, checking symptoms is often the primary activity;
- Schools report frustration with daily full symptom checks – kids too!
- Is there a better way?

Neuropsychological factors

In mTBI primary focus
- Memory (specifically working memory)
  - Attention is implicated
- Speed (processing speed and reaction time)
- Do not ignore affective status!
Neuropsychological tests

• Screens functions associated with mTBI:
  – Learning & memory
  – Processing speed and efficiency
  – Reaction time
  – Attention

  – Tests like ImPACT provide screening
  • identify if there is a problem, not exactly what the problem is.
  • For instance, learning & memory have many component parts that are not specifically tested.
  – Some aspects of test scores require expert interpretation
  • (test companies make it sound like anyone can administer and interpret...not true)

Balance Assessment

Vision O-M

Vestibular

Proprioception
Vestibulo-Ocular dysfunction

- “Clinical predictors of vestibulo-ocular dysfunction in pediatric sports-related concussion”, Ellis et al, 2017

- VOD and anxiety are over-represented in cases of prolonged recover.
- 43% with PCS were identified as having VOD
  - Subjective complaints of dizziness, diplopia, blurred vision, etc
  - Objective findings of abnormal near point of convergence, smooth pursuits, saccades, or vestibulo-ocular reflex testing

- Independent predictors of VOD at initial consultation included female sex, preinjury history of depression, posttraumatic amnesia, and presence of dizziness, blurred vision, or difficulty focusing at the time of injury

Balance Error Scoring System: BESS

**Conditions**
- Six 20 sec trials
- 3 different stances (double, single, tandem)
- 2 different surfaces (firm, foam)

**Recorded Errors**
- Hands off hips
- Opening eyes
- Step, stumble, or fall
- Excessive leg movement
- Out of testing position for >5 secs.
BESS

Determining Recovery

- Symptoms: back to “baseline”
  - No return after step-wise progression
- Balance: back to “baseline”
  - Known practice effects and no good psychometric adjustment
  - Error scores are variable and subjective, so difficult to gauge
- Oculo-motor
  - Not well established clinically
- Cognition: back to “baseline”...?
ImPACT is not as simple as a “Red Score”

<table>
<thead>
<tr>
<th>Exam Type</th>
<th>Baseline</th>
<th>Baseline</th>
<th>Post-Injury 1</th>
<th>Post-Injury 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Date Tested</td>
<td>07/19/2013</td>
<td>08/28/2014</td>
<td>11/10/2015</td>
<td>12/03/2015</td>
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<tr>
<td>Last Concussion</td>
<td>11/03/2015</td>
<td>11/03/2015</td>
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<td>Exam Language</td>
<td>English</td>
<td>English</td>
<td>English</td>
<td>English</td>
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<tr>
<td>Test Version</td>
<td>2.1</td>
<td>2.1</td>
<td>2.1</td>
<td>2.1</td>
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</table>

<table>
<thead>
<tr>
<th>Composite Scores</th>
<th>Baseline</th>
<th>Baseline</th>
<th>Post-Injury 1</th>
<th>Post-Injury 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Memory composite (vertical)</td>
<td>65</td>
<td>67</td>
<td>85</td>
<td>70</td>
</tr>
<tr>
<td>Memory composite (visual)</td>
<td>80</td>
<td>82</td>
<td>85</td>
<td>80</td>
</tr>
<tr>
<td>Visual motor speed composite</td>
<td>70</td>
<td>75</td>
<td>78</td>
<td>75</td>
</tr>
<tr>
<td>Reaction time composite</td>
<td>0.68</td>
<td>0.58</td>
<td>0.72</td>
<td>0.73</td>
</tr>
<tr>
<td>Impulse control composite</td>
<td>1</td>
<td>1</td>
<td>11</td>
<td>6</td>
</tr>
<tr>
<td>Total Symptom Score</td>
<td>1</td>
<td>16</td>
<td>20</td>
<td>9</td>
</tr>
</tbody>
</table>

Cognitive Efficiency Index: 0.24 0.49 0.32 0.32

Both significant

When? Why?

- Timing is a critical component of concussion management.
- The injury itself has a relatively narrow window;
- Assessing at proper time-points is helpful
  - But not always possible.

[Diagram: Neurometabolic Cascade]
When?

• Broglio & Puetz (2008) noted that SAC was most sensitive immediately after injury, with paper & pencil or computer neuropsych testing better after 2 days.

• Balance assessment is sensitive immediately after and resolves in 3-5 days
  – Method of assessment matters, with more sensitive sway measures unknown at this point

A look at diagnostic certainty by time

Many ways to assess diagnostic certainty

• Post-test probabilities
  1. Pretest odds (below) = pretest probability / (1 - pretest probability)
  2. Posttest odds = Pretest odds x likelihood ratio
  3. Posttest probability = Posttest odds / (posttest odds + 1)

• Pretest probability
  – Based on prevalence rate (.14)
  – Sensitivity/specificity of tests
  – Calculate likelihood ratio+

• Post-test probability is probability of a positive diagnosis if tests are positive (indicate injury)
Is diagnostic accuracy important?

- Clinically – yes, because the patient deserves accuracy;
- The number of concussions “diagnosed” can have an effect on sports-future;
- Research – need to know which are exemplar cases and weed out questionable ones (cause error).
- BUT clinical life sometimes requires being conservative when unsure.

Absolutely!

WHAT tests are best for diagnosis & WHEN?

Post-test probabilities +

<table>
<thead>
<tr>
<th>Sideline/day of injury:</th>
<th>Post-test probabilities +</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sideline/day of injury:</td>
<td>Post-test probabilities +</td>
</tr>
<tr>
<td>SAC + BESS = .82</td>
<td>Post-test probabilities +</td>
</tr>
<tr>
<td>GSC = .92</td>
<td>Post-test probabilities +</td>
</tr>
<tr>
<td>Day 1</td>
<td>Post-test probabilities +</td>
</tr>
<tr>
<td>SAC + BESS + ImPACT =</td>
<td>Post-test probabilities +</td>
</tr>
<tr>
<td>.93</td>
<td>Post-test probabilities +</td>
</tr>
<tr>
<td>GSC = .88</td>
<td>Post-test probabilities +</td>
</tr>
<tr>
<td>Day 2</td>
<td>Post-test probabilities +</td>
</tr>
<tr>
<td>SAC + BESS + ImPACT =</td>
<td>Post-test probabilities +</td>
</tr>
<tr>
<td>.82</td>
<td>Post-test probabilities +</td>
</tr>
<tr>
<td>GSC = .73</td>
<td>Post-test probabilities +</td>
</tr>
<tr>
<td>Day 3</td>
<td>Post-test probabilities +</td>
</tr>
<tr>
<td>SAC + BESS + ImPACT =</td>
<td>Post-test probabilities +</td>
</tr>
<tr>
<td>.93</td>
<td>Post-test probabilities +</td>
</tr>
<tr>
<td>GSC = .88</td>
<td>Post-test probabilities +</td>
</tr>
</tbody>
</table>
Post-test probabilities: GSC compared to combined tests

*Sideline & Day 5 – no ImPACT

GSC + Tests = .99

Effect of combining tests
GSC, BESS, SAC/ImPACT (when all positive for dx)

Day2 w/SAC  w/ImP  Day 3  Day 5
Day2 w/SAC  w/ImP

Sideline  Day 1  Day 2  Day 3  Day 5
0.998  0.935  0.844  0.999  0.997  0.993
The first 48 hours

• When symptoms plus all tests are administered, diagnostic probability = .99 in day 1-3.
• Drops off after day 3

Who

• In the mad rush, who does what?
• And does it matter
  – Clinical reasons
  – Legal reasons
  – Ethical reasons
Who should be making what decisions?

• State laws generally require a licensed health-care provider to make diagnoses and final return to play decisions.
• Many include a requirement for training in mTBI/concussions.
• Head’s Up Concussion Clinicans Training
• https://www.cdc.gov/concussion/HeadsUp/clinicians/index.html

Shameless plug:
http://dhhs.ne.gov/publichealth/ConcussionManage/Pages/cr00.asp
Ideal concussion management division of labor

- Diagnosis by licensed health care professional
- Symptoms should be reviewed medically;
- Balance testing, particularly when using sway metrics, should be interpreted by balance experts (PT, Aud., etc);
- Neuropsych tests should be reviewed by licensed neuropsychologists
- * A case coordinator is ideal…JT

Prolonged Recovery

- A small but non-trivial proportion do not recover in expected time-frames.
- Referral to specialists, based on signs and symptoms is recommended;
- Chronic headache is the most common persistent symptom.
Vestibular, Oculo-motor, & Anxiety Issues

• Research indicates that a small but significant proportion of cases have persistent vestibular or VOM disturbance;
  – These require more sophisticated assessment and treatment if persistent beyond 2+ weeks
  – Neuro-opthamology
• An overlapping subset have anxiety
  – Similarly, anxiety can prolong recovery and should be addressed with CBT
  – Clinical psychologist/psychiatrist

Who is a licensed health care provider under Nebraska Law?

• Licensed health care professional means a physician or licensed practitioner under the direct supervision of a physician, a certified athletic trainer, a neuropsychologist, or some other qualified individual who (a) is registered, licensed, certified, or otherwise statutorily recognized by the State of Nebraska to provide health care services and (b) is trained in the evaluation and management of traumatic brain injuries among a pediatric population
Many potential team members

<table>
<thead>
<tr>
<th>Profession</th>
<th>Expertise</th>
</tr>
</thead>
<tbody>
<tr>
<td>PCP</td>
<td>health history; basic medicine (body as a biological system)</td>
</tr>
<tr>
<td>Neurologist</td>
<td>brain structure and function; diagnose disease</td>
</tr>
<tr>
<td>Orthopedist/</td>
<td>body mechanics and injury</td>
</tr>
<tr>
<td>Sports Med Physician</td>
<td></td>
</tr>
<tr>
<td>Neuropsychologist</td>
<td>assess brain function; relation of brain to behavior, behavioral treatment</td>
</tr>
<tr>
<td>ATC</td>
<td>athletic injury treatment</td>
</tr>
<tr>
<td>Physical Therapist</td>
<td>“below the waist”; motor systems; balance</td>
</tr>
<tr>
<td>Occupational Therapist</td>
<td>“above the waist” adaptive behavior; functional assessment</td>
</tr>
<tr>
<td>Speech- Language Pathologist</td>
<td>speech and language assessment; language rehab including cognition related to language</td>
</tr>
<tr>
<td>Audiologist</td>
<td>vestibular system; auditory inputs</td>
</tr>
<tr>
<td>Psychologist</td>
<td>Therapy, sleep hygiene, anxiety management</td>
</tr>
</tbody>
</table>

Expertise is valuable

- Let experts exercise their expertise
- Incorrect interpretations can cause clinical & liability issues.
Take away points

• Assessment is more than a test
• Different procedures at different points in the process
  – identification, management, recovery
• Multi-domain assessment is vital
  – Symptom report is not enough
  – Kids may not report accurately
  – A test score is not enough
• Accuracy in administration is vital
• Timing makes a difference
• Use experts to provide best practice and protect from liability (when in doubt, ask)

Thank you!

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