Concussion Update 2014
Evaluation and Management

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Objectives

• Describe the natural history of concussion
• Apply multimodal assessment to concussion patient
• Review updated guidelines for sports concussion
• Identify patients who may benefit from additional rehabilitative strategies.
Case #1

• 17 yo elite football player
• 3 concussions
• 1st concussion @ age 11
  – Fell off his bike and down a hill. No LOC. Anterograde amnesia for 1 hour. Returned to usual activities within 6 days. No games missed. Didn’t see a physician.
• 2nd concussion @ age 15
  – Loss of consciousness for 15 minutes. Missed rest of season. Returned to play.
• 3rd concussion @ age 17
  – Multiple concussive impacts during a single game with repeated exposure. Worried about his college scholarship
Case Scenario #1

• What symptoms?
• How should we assess his recovery?
• How should we approach return to school?
• How should we approach return to play?
• What other data would be helpful in guiding our recommendations?
• How should we follow the course of recovery?
• What interventions may be helpful?
Definition of Concussion

“Concussion is recognized as a clinical syndrome of biomechanically induced alteration of brain function, typically affecting memory and orientation, which may involve loss of consciousness (LOC).”

AAN Concussion Guideline, 2013

• LOC is NOT required

• Structural injury NOT required
  – Functional disturbance

• Direct head injury is NOT required
  – Impact can be anywhere along the body
  – Transmitted to the head
  – Usually results in sudden movement of the head
Pathophysiology

- Direct or indirect impact (impulse force) to head
- Horizontal vs rotational movement
- Neurotransmitter release
- Hypermetabolic state
Epidemiology

- 1 to 3.8 million/year in the US
  - Underreported in athletes
  - Under-recognition

- Causes by age
  - Young (Children/Teens) → FALLS (sports and bike accidents)
  - Middle-aged → MVA and assaults
  - Not so young → FALLS

- Military: 15-22% wounded soldiers with TBI
Scope: mTBI and Sports

• Estimated 1.8 to 3.6 million sports related concussions annually in the US

• Each year at least 60,000 high school athletes sustain concussions

• Most common cause of head trauma in children under 18, and the second most common cause in adults 18-65
“He’s clear, coach!”
Which of the following high school sports has the highest rate of concussion as a percentage of all injuries within each sport?

A. baseball
B. gymnastics
C. volleyball
D. track and field
E. cheerleading
Answer E

• About 21% of all injuries suffered among high-school cheerleaders may be attributed to sports concussion.

Concussion as a Percentage of All Injuries

Which of the following is MOST likely to increase the risk of recurrent sport-related concussion?

A. Caffeine use

B. Less than 8 hours of sleep per night

C. Physical rest

D. Prior concussion

E. Playing video games
Answer is D

• A history of concussion is a highly probable risk factor for recurrent concussion.

• It is also highly likely that there is an increased risk for repeat concussion in the first 10 days after an initial concussion.

• Patients with a history of a previous concussion, particularly those with recent or multiple concussions, are at increased risk for prolonged symptoms after concussion.

Delayed Recovery Associated with TIMING of Prior Concussion

Eisenberg MA et al. *Pediatrics* 2013 Jul;132(1):8-17
Delayed Recovery Associated with NUMBER of Prior Concussions

Eisenberg MA et al. *Pediatrics* 2013 Jul;132(1):8-17
2013 AAN Sports Concussion Guidelines: Risks/Pre-participation counseling

• Highest risk sports
  – Football, rugby, hockey, and soccer

• Gender
  – Female soccer and basketball players have a higher risk of concussion than their male counterparts

• History of concussion is a risk factor for recurrent concussion especially in the first 10 days post injury

• Helmets reduce concussion risk in hockey, rugby and lacrosse.
  – Soft head protectors likely don’t reduce concussion risk

• Age, position do not clearly increase concussion risk
Concussion Evaluation

• History
  – Circumstances of concussion / mechanism of injury (Prevention)
    – LOC / Amnesia
    – Mechanism
    – Location (oblique, occipital, frontal, etc.)
    – Headgear
  – Parent / observer vs. patient report
  – Missed school / work / sport
  – Medications
  – Symptom triggers
  – Prior concussion
# Graded Symptom Checklist

<table>
<thead>
<tr>
<th>SOMATIC  (10)</th>
<th>COGNITIVE  (8)</th>
<th>EMOTIONAL  (4)</th>
<th>SLEEP  (4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Headache *</td>
<td>Feeling mentally “foggy” *</td>
<td>Irritability *</td>
<td>Drowsiness *</td>
</tr>
<tr>
<td>Nausea *</td>
<td>Felling slowed down *</td>
<td>Sadness *</td>
<td>Sleeping more than usual</td>
</tr>
<tr>
<td>Vomiting *</td>
<td>Difficulty concentrating *</td>
<td>More emotional *</td>
<td>Sleeping less than usual</td>
</tr>
<tr>
<td>Balance problems *</td>
<td>Difficulty remembering *</td>
<td>Nervousness *</td>
<td>Difficulty falling asleep *</td>
</tr>
<tr>
<td>Visual problems *</td>
<td>Forgetful of recent information</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fatigue *</td>
<td>Confused about recent events *</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sensitivity to light *</td>
<td>Answer questions slowly</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sensitivity to sound *</td>
<td>Repeat questions</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dazed</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stunned</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
**Purpose:** Examine the proportion of concussed athletes with impairment disagreements across various clinical concussion assessment measures.

**Methods:** N= 100 concussed collegiate–aged athletes assessed at BL & <72 hrs post-injury on GSC, computerized NP, and balance

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**Table 3.** Frequency of reported symptoms (somatic, neurobehavioral, and cognitive) at postinjury assessment

<table>
<thead>
<tr>
<th>Symptoms</th>
<th>Frequency, no. (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Somatic symptoms</td>
<td></td>
</tr>
<tr>
<td>Headache</td>
<td>56 (60.0)</td>
</tr>
<tr>
<td>Nausea</td>
<td>12 (13.0)</td>
</tr>
<tr>
<td>Vomiting</td>
<td>0 (0.0)</td>
</tr>
<tr>
<td>Balance problems</td>
<td>31 (33.0)</td>
</tr>
<tr>
<td>Sensitivity to light</td>
<td>24 (26.0)</td>
</tr>
<tr>
<td>Sensitivity to noise</td>
<td>20 (22.0)</td>
</tr>
<tr>
<td>Tinnitus</td>
<td>5 (5.0)</td>
</tr>
<tr>
<td>Dizziness</td>
<td>32 (34.0)</td>
</tr>
<tr>
<td>Blurred vision</td>
<td>17 (18.0)</td>
</tr>
<tr>
<td>Neck pain</td>
<td>35 (37.0)</td>
</tr>
<tr>
<td>Neurobehavioral</td>
<td></td>
</tr>
<tr>
<td>symptoms</td>
<td></td>
</tr>
<tr>
<td>Sleep disturbance</td>
<td>24 (26.0)</td>
</tr>
<tr>
<td>Drowsiness</td>
<td>40 (43.0)</td>
</tr>
<tr>
<td>Fatigue</td>
<td>23 (25.0)</td>
</tr>
<tr>
<td>Sadness</td>
<td>6 (6.0)</td>
</tr>
<tr>
<td>Irritable</td>
<td>19 (20.0)</td>
</tr>
<tr>
<td>Cognitive symptoms</td>
<td></td>
</tr>
<tr>
<td>Difficulty concentrating</td>
<td>46 (49.0)</td>
</tr>
<tr>
<td>Difficulty remembering</td>
<td>31 (33.0)</td>
</tr>
</tbody>
</table>

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**Table 4.** Testing measures means (SD)

<table>
<thead>
<tr>
<th>Test Outcome</th>
<th>Preseason Baseline, Mean (SD)</th>
<th>After Injury, Mean (SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Simple reaction time 1*</td>
<td>222.5 ±36.3</td>
<td>225.9 ±36.2</td>
</tr>
<tr>
<td>Simple reaction time 2*</td>
<td>226.0 ±37.9</td>
<td>224.9 ±37.4</td>
</tr>
<tr>
<td>Math processing*</td>
<td>21.4 ±6.2</td>
<td>22.9 ±7.3</td>
</tr>
<tr>
<td>Match to sample*</td>
<td>39.2 ±12.3</td>
<td>38.8 ±15.5</td>
</tr>
<tr>
<td>Procedural reaction time*</td>
<td>93.3 ±21.4</td>
<td>103.3 ±16.3</td>
</tr>
<tr>
<td>Code substitution*</td>
<td>49.3 ±9.1</td>
<td>49.9 ±9.9</td>
</tr>
<tr>
<td>Sternberg memory search*</td>
<td>73.9 ±17.5</td>
<td>71.8 ±16.9</td>
</tr>
<tr>
<td>Symptom severity total score</td>
<td>4.8 ±6.8</td>
<td>9.6 ±9.8</td>
</tr>
<tr>
<td>Sensory organization test composite score</td>
<td>80.1 ±6.1</td>
<td>77.76 ±12.3</td>
</tr>
</tbody>
</table>

*Presented as a throughput score (no. of correct responses per minute), so a higher score is better.
Diagnosis – Initial Examination

1. Mental Status
   5 word recall
   Months in reverse
   SCAT3 vs child SCAT 3 (age-tailored)

2. Balance
   mBESS/Sway index
   Postural stability

3. Gait

4. Examination of head and cervical spine
Diagnosis: Neurological Examination

- Tailored to Age Group
  - Cranial Nerves
  - Cerebellar
    - Rapid alternating movements
    - F-N-F
  - Vestibular/Ocular Responses
    - Dynamic Visual Acuity/VOR Gaze Stability
    - Saccades
    - Near Point Convergence (<6cm, 6-10cm, >10cm)
    - Optokinetic Tape
Balance Error Scoring System (BESS)

Clinical Test Battery
Six 20 sec trials using 3 different stances (double, single, tandem) on 2 different surfaces (firm, foam)

Recorded Errors
- Hands lifted off iliac crests
- Opening eyes
- Step, stumble, or fall
- Moving into >30 deg. of hip flexion or abduction
- Remaining out of testing position for >5 secs.
BESS Scores – Change from Baseline (n=203 Concussed HS/College Athletes)

Estimated from Linear Mixed Model with X-axis in log [(Day x 24 hours) +1]
Non-contrast head CT can be useful in the emergency department to evaluate for more significant traumatic brain injury, such as intracranial hemorrhage, in concussion patients who present with loss of consciousness or focal neurological deficit.

A. True
B. False
Answer is A (True)

Imaging studies

• CT in first 24-48 hours
  – Cheap, more readily available
  – Detect fracture
  – Increased sensitivity for intracranial hemorrhage

• MRI in 48-72 hours
  – Hematoma
  – Contusion
  – Axonal injury

• fMRI (experimental)
**Suggested CT Algorithm**

- **GCS=14 or other signs of altered mental status†, or signs of basilar skull fracture**
  - Yes: 14.0% of population, 4.3% risk of ciTBI
  - No: 58.3% of population, <0.05% risk of ciTBI

- **History of LOC, or history of vomiting, or severe mechanism of injury‡, or severe headache**
  - Yes: 27.7% of population, 0.9% risk of ciTBI
  - No: CT not recommended

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Suggested Checklist For Imaging

- GCS<15
- N/V
- Severe HA
- Severe mechanism of injury
- Skull depression/fracture
- Focal neurological deficits
- Worsening symptoms
Which of the following combination methods for evaluating concussed patients likely has the highest signal detection rates for ongoing symptoms?

A. Balance function testing, graded symptom checklist, and motor examination

B. Balance function testing, graded symptom checklist, and sensory examination

C. Neuropsychological testing, graded symptom checklist, and balance function testing

D. Neuropsychological testing, graded symptom checklist, and motor examination
• Paper-and-Pencil Neuropsychological testing when combined with a graded symptom checklist, and balance function testing are approximately 96% sensitive for a return to normal baseline neurological function after concussion.

Neuropsychiatric testing

- Objective measure in assessing recovery
- Paper and pencil NP testing
- Immediate Post-concussion Assessment and Cognitive Testing (ImPACT) most widely used
- Detects residual cognitive effects in asymptomatic patients
  - Increases sensitivity of detecting neurocognitive effects of concussion by 19%
- Never use in isolation
- Self-reported “cognitive impairment” was reported by nearly half of the concussed athletes, yet NP testing did not identify many of these athletes as impaired. 30% of the athletes who were impaired on the GSC would have cleared if only NP testing were utilized.

- Nearly 1/3 of the concussed athletes reported either a “balance problem” or “dizziness” but the SOT did not identify several as impaired. >30% of the athletes who were impaired on the GSC would have cleared if only SOT were utilized.

- GSC should be administered by a trained health care provider, and NOT simply placed in front of an athlete for them to complete. It will likely not ascertain the same information as a clinician administered GSC.

- Unless needed for academic or other outside performance based decisions, using computerized NP testing while an athlete is still symptomatic is not clinically beneficial.
# CNT on Day of Injury: Critical Review Results

## Comparing Signal Detection Rates

<table>
<thead>
<tr>
<th>% of athletes</th>
<th>Symptom Checklist</th>
<th>PNP NP</th>
<th>ImpACT</th>
<th>HM-CRI</th>
<th>Balance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abnormal, Symptomatic</td>
<td>68.0 (symptomatic)</td>
<td>60.9</td>
<td>45.8</td>
<td>60.7</td>
<td>44.4</td>
</tr>
<tr>
<td>Abnormal, Asymptomatic</td>
<td>NA</td>
<td>26.1</td>
<td>16.7</td>
<td>28.6</td>
<td>17.4</td>
</tr>
<tr>
<td><strong>ABNORMAL TEST DETECTION</strong></td>
<td><strong>87.0</strong></td>
<td><strong>62.5</strong></td>
<td><strong>89.3</strong></td>
<td><strong>61.8</strong></td>
<td></td>
</tr>
<tr>
<td>Normal, Symptomatic</td>
<td>13.0</td>
<td>25.0</td>
<td>0.0</td>
<td>23.8</td>
<td></td>
</tr>
<tr>
<td>Normal, Asymptomatic</td>
<td>32.0 (asymptomatic)</td>
<td>0.0</td>
<td>12.5</td>
<td>10.7</td>
<td>14.3</td>
</tr>
</tbody>
</table>

*Impairment based on ≥1 test impaired; Piland version of symptom checklist

## Power of the Multi-Modal Approach

### Sensitivity of NP When Combined with Symptom Inventory and Balance Testing

<table>
<thead>
<tr>
<th>Paper/Pencil</th>
<th>ImpACT</th>
<th>HM-CRI</th>
</tr>
</thead>
<tbody>
<tr>
<td>95.7%</td>
<td>91.7%</td>
<td>89.3%</td>
</tr>
</tbody>
</table>

Broglio, Macchiocci, Ferrara, 2007
Concussion Evaluation

• Reaction Time
  – Simple RT
  – Choice RT

• Cognitive Testing - Tailored to Age Group
  – Computerized NP testing (Axon, Cogstate, ImPACT, etc.)
  – Paper and Pencil Neuropsychological Testing
C3 Simple Reaction Time Task

• Stoplight-like task
  – Quick adoption

• 1 Stimulus, 1 Response

• Variable Foreperiod controls anticipation

• Touch and Release minimizes influence of motor time on reaction time

• Lower bound at 100 msec. eliminates well-timed pure anticipation trials

• Upper bound at 500 msec. eliminates distraction trials
Concussion Management

• Symptomatic Management / Education
  – Physical rest
  – Avoidance of symptomatic activity in hyper-acute, acute, and subacute stages
Management

- Targeted Symptomatic Therapy / Goal-Directed
  - Reduction of Triggers
  - Headache treatment
    - Migraine, Tension-Type, Mixed, Other
  - Sleep
    - Hygiene, Medication
  - Occipital Neuralgia
    - Neck PT, GON Blocks
  - Fatigue
    - Rest, Exertional Recovery, Amantadine
  - Depression
    - Psychotherapy, Sertraline
  - POTS (postural orthostatic tachycardia syndrome)
Management

• Physical Therapy / Vestibular Rehabilitation
  – Treat identified dizziness, balance, and visual stability complaints
  – Treat cervical pain, and cervicogenic headache

• Cognitive rehabilitation
  – Targeted therapy to improve functional deficits documented on NP testing

• Scheduled short-term and intermediate-term follow-up
  – Develop detailed follow-up plans

• Educate
  – Prevention
  – Long-term sequelae
Fresnel Glasses
RETURN TO LEARN

- Stepwise increase in cognitive tasks
  - Cognitive rest
  - Period of school absence
  - Increase cognitive activities at home
- Gradual return to school
  - Half-days, only some classes
Management

• Return to Work
  — Resumption of physical activity when asymptomatic (or stable) at rest
  — Stepwise increase in cognitive tasks

• Return to Play
  — **Graded exertional testing and recovery**
    1. No activity
    2. Light aerobic exercise
    3. Noncontact training drills
    4. Full contact practice
    5. Return to play
Graded Exertional Recovery

• Stage 1A  Early Symptomatic (Rest)
• Stage 1B  Late Symptomatic (Rest +)
• Stage 2  Light Exertion (40-60% PPHR)
• Stage 3  Heavy Exertion (60-80%) PPHR
• Stage 4  Performance Level / Contact (80-90% PPHR)
• Stage 5  Return to unrestricted play
Exertional Testing and Recovery

BORG 6-20 Rate of Perceived Exertion Scale (RPE)
## Timing of Return to Play

Percentage of Athletes Who Returned to Play at Given Time Points

<table>
<thead>
<tr>
<th>Timing of Return to Play</th>
<th>Percentage of All Concussed Athletes</th>
<th>Percentage of Athletes Returned to Play by Athletic Trainer</th>
<th>Percentage of Athletes Returned to Play by Physician</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-2 d</td>
<td>4.7</td>
<td>6.4</td>
<td>2.5</td>
</tr>
<tr>
<td>3-6 d</td>
<td>20.7</td>
<td>25.5</td>
<td>14.9</td>
</tr>
<tr>
<td>7-9 d</td>
<td>30.0</td>
<td>31.9</td>
<td>28.7</td>
</tr>
<tr>
<td>10-21 d</td>
<td>34.5</td>
<td>31.1</td>
<td>39.3</td>
</tr>
<tr>
<td>&gt;22 d</td>
<td>4.5</td>
<td>2.5</td>
<td>6.7</td>
</tr>
<tr>
<td>Medical disqualification for season</td>
<td>5.4</td>
<td>2.7</td>
<td>7.1</td>
</tr>
<tr>
<td>Medical disqualification for career</td>
<td>0.3</td>
<td>0.0</td>
<td>0.7</td>
</tr>
</tbody>
</table>

- **89.9%**

Athletes with suspected concussion should be permitted to return to play on the day of injury, if their performance is integral to the success of the team.

A. True  
B. False
Answer B (False)

• In order to diminish the risk of recurrent injury, individuals supervising athletes should prohibit an athlete with concussion from returning to play/practice (contact-risk activity) until the concussion has resolved.

Case #1

• 17 yo elite football player

• 3 concussions

• 1\textsuperscript{st} concussion @ age 11
  – Fell off his bike and down a hill. No LOC. Anterograde amnesia for 1 hour. Returned to usual activities within 6 days. No games missed. Didn’t see a physician.

• 2\textsuperscript{nd} concussion @ age 15
  – Loss of consciousness for 15 minutes. Missed rest of season. Returned to play.

• 3\textsuperscript{rd} concussion @ age 17
  – Multiple concussive impacts during a single game with repeated exposure. Worried about his college scholarship
3T SWI

- Compared to MRI after 2nd concussion, interval MRI shows more chronic appearing microhemorrhages w/ additional areas of contusion

- 3, 6, and 12 month follow-up studies stable

- Patient reports he is asymptomatic at 3 months
MRI Morphometry in Mild TBI

• 1 in 20 concussed patients may have evidence cerebral microhemorrhages on 3T MRI

• Specific areas of reduced fractional anisotropy correlate with severity of post-concussive symptoms

• Specific areas of increased mean diffusivity correlate with severity of post-concussive symptoms

• Inconsistent correlation between fiber tract disruption, FA, MD, and abnormalities on NP testing

Chronic neurological symptoms

ATHLETE WITH CHRONIC NEURO SYMPTOMS

- Neurological disease
- Medical comorbidities
- Mental health issues
- Illicit drug use
- Alcohol
- Dementia / MCI
- Neurobehavioral
- Quality of life
- Malingering
- Other

CONCUSSION/RECURRENT CONCUSSION

- RECOVERY
- PERSISTENT Sx
- PCS (DSM4)
- PERMANENT Sx
- CTE
Chronic Traumatic Encephalopathy

• Presents years to decades later
• Affects mobility, cognition, behavior
• Tau+ neurofibrillary inclusions and neuropil threads
• Can result in dementia, speech disturbances or movement disorders
Chronic Traumatic Encephalopathy
Other Complications

• Post concussive syndrome
  – Persistence of symptoms beyond 6 weeks
  – Risk factors: Comorbid psychiatric disease, intense emotions and symptoms, increased age

• Second-impact syndrome
  – Second head trauma while still recovering from subacute concussive event
  – May result in cerebral edema and death
Skull Fracture and Cerebral Venous Thrombosis

- Multidetector CT venography depicted thrombosis of 98 dural sinuses or jugular bulbs in 57 (40.7%) of the 140 patients with skull fractures extending to a dural sinus or jugular bulb.

Systemic Issues in Concussion

- Polytrauma secondary to MVA
- Blunt abdominal trauma causing splenic hemorrhage in sports concussion
- Anterior pituitary dysfunction may occur in up to 40-50% of moderate to severe traumatic brain injury patients

Delayed healing of fractures due to growth hormone failure

May respond to growth hormone substitution therapy
Case #2

• 45-year-old male Ortho physician
• Bike injury with closed head trauma
  – But no clear LOC
• Fugue state
• GCS = 15
• No focal neuro deficits
  – But patient is sleepy on examination
• Imaging?
Case #2

- Small SAH on head CT and admitted to ICU
- MRI brain on day 2 with no underlying contusion
- Discharged to home in 96 hrs in stable condition
- Followup neurological examination:
  - Difficulty with orientation
  - High BESS score
  - Normal gait
  - No skull fracture or neck injury
- Recommendations?
Case #2

• Dizziness and imbalance are primary complaints
  —Vestibular and physical therapy for gait/balance training

• NSAIDs for HA

• Stayed home for one month
  —Cognitive and physical rest

• Returned to OR in 6 weeks

• Now at baseline except for occasional word finding difficulty, eyebrow never grew back
because some times you kind of need that other haft of your eye brow.

=CHLOE
Summary of evidence-based guideline update: Evaluation and management of concussion in sports

Risks for concussion

- **Type of sport.** Among commonly played team sports with data available for systematic review, there is strong evidence that concussion risk is greatest in football, rugby, hockey, and soccer.

- **Gender.** Clear differences in concussion risk between male and female athletes have not been demonstrated for many sports; however, in soccer and basketball there is strong evidence that concussion risk appears to be greater for female athletes.

- **Prior concussion.** There is strong evidence indicating that a history of concussion/mTBI is a significant risk factor for additional concussions. There is moderate evidence indicating that a recurrent concussion is more likely to occur within 10 days after a prior concussion.
Recommendations: Preparticipation Counseling, cont.

**Risks for concussion**

- **Equipment.** There is moderate evidence indicating that use of a helmet (when well fitted, with approved design) effectively reduces, but does not eliminate, risk of concussion and more-serious head trauma in hockey and rugby; similar effectiveness is inferred for football. There is no evidence to support greater efficacy of one particular type of football helmet, nor is there evidence to demonstrate efficacy of soft head protectors in sports such as soccer or basketball. Mouth guards protect against dental injuries but not against concussions.

- **Age or competition level.** There is insufficient evidence to make any recommendation as to whether age or competition level affects the athlete’s overall concussion risk.

- **Position.** Data are insufficient to support any recommendation as to whether position increases concussion risk in most major team sports.
Recommendations: Suspected Concussion

*Use of screening tools*

- Inexperienced LHCPs should be instructed in the proper administration of standardized validated sideline assessment tools. This instruction should emphasize that these tools are only an adjunct to the evaluation of the athlete with suspected concussion and cannot be used alone to diagnose concussion. These providers should be instructed by experienced individuals (LHCPs) who themselves are licensed, knowledgeable about sports concussion, and practicing within the scope of their training and experience, designated by their organization/institution in the proper administration of the standardized validated sideline assessment tools *(Level B)*.

- In individuals with suspected concussion, these tools should be utilized by sideline LHCPs and the results made available to clinical LHCPs who will be evaluating the injured athlete *(Level B)*.
Recommendations: Suspected Concussion, cont.

Use of screening tools

- Team personnel (e.g., coaching, athletic training staff, sideline LHCPs) should immediately remove from play any athlete suspected of having sustained a concussion, in order to minimize the risk of further injury (Level B).
- Team personnel should not permit the athlete to return to play until the athlete has been assessed by an experienced LHCP with training both in the diagnosis and management of concussion and in the recognition of more-severe traumatic brain injury (TBI) (Level B).
- LHCPs caring for athletes might utilize individual baseline scores on concussion assessment tools, especially in younger athletes, those with prior concussions, or those with preexisting learning disabilities/ADHD, as doing so fosters better interpretation of postinjury scores (Level C).
Recommendations: Suspected Concussion, cont.

**Use of neuroimaging**

- CT imaging should not be used to diagnose sport-related concussion but might be obtained to rule out more serious TBI such as an intracranial hemorrhage in athletes with a suspected concussion who have loss of consciousness, posttraumatic amnesia, persistently altered mental status (Glasgow Coma Scale <15), focal neurologic deficit, evidence of skull fracture on examination, or signs of clinical deterioration (**Level C**).
Recommendations: Diagnosed Concussion

Return to play – risk of recurrent concussion

- In order to diminish the risk of recurrent injury, individuals supervising athletes should prohibit an athlete with concussion from returning to play/practice (contact-risk activity) until an LHCP has judged that the concussion has resolved (Level B).
- In order to diminish the risk of recurrent injury, individuals supervising athletes should prohibit an athlete with concussion from returning to play/practice (contact-risk activity) until the athlete is asymptomatic off medication (Level B).
Recommendations: Diagnosed Concussion, cont.

Return to play – age effects

- Individuals supervising athletes of high school age or younger with diagnosed concussion should manage them more conservatively regarding return to play (RTP) than they manage older athletes (Level B).
- Individuals using concussion assessment tools for the evaluation of athletes of preteen age or younger should ensure that these tools demonstrate appropriate psychometric properties of reliability and validity (Level B).
Recommendations: Diagnosed Concussion, cont.

Return to play – concussion resolution and graded physical activity

- Clinical LHCPs might use supplemental information, such as neurocognitive testing or other tools, to assist in determining concussion resolution. This may include but is not limited to resolution of symptoms as determined by standardized checklists and return to age-matched normative values or an individual’s preinjury baseline performance on validated neurocognitive testing (Level C).

- LHCPs might develop individualized graded plans for return to physical and cognitive activity, guided by a carefully monitored, clinically based approach to minimize exacerbation of early postconcussive impairments (Level C).
Recommendations: Diagnosed Concussion, cont.

Retirement from play after multiple concussions

- LHCPs might refer professional athletes with a history of multiple concussions and subjective persistent neurobehavioral impairments for neurologic and neuropsychological assessment (Level C).

- LCHPs caring for amateur athletes with a history of multiple concussions and subjective persistent neurobehavioral impairments might use formal neurologic/cognitive assessment to help guide retirement-from-play decisions (Level C).
Recommendations: Diagnosed Concussion, cont.

Retirement from play after multiple concussions

- LHCPs should counsel athletes with a history of multiple concussions and subjective persistent neurobehavioral impairment about the risk factors for developing permanent or lasting neurobehavioral or cognitive impairments (**Level B**).

- LHCPs caring for professional contact sport athletes who show objective evidence for chronic/persistent neurologic/cognitive deficits (such as seen on formal neuropsychological testing) should recommend retirement from the contact sport to minimize risk for and severity of chronic neurobehavioral impairments (**Level B**).
Summary

• “When in doubt, sit them out.”

• CT imaging decision rules may assist clinicians in reducing unnecessary radiation exposures and cost

• Multimodal evaluation improves diagnostic accuracy after concussion

• Repetitive concussive and subconcussive impacts have long term effects on brain structure and function

• Advances in neuroimaging are already part of the evolving paradigm in the management of patients with both sport and non-sport concussion
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