2019 Concussion Update

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Introduction

• Sports related concussion (SRC) continue to be a cause of concern for physicians based upon media coverage and continued legislation.
• The lack of definitive outcomes-based data continues to rely on the best available evidence and consensus integrated with clinical experience and patient value and outcomes.
Papers Reviewed

Who Should Evaluate and Manage SRC?

- Healthcare professionals with appropriate training and experience; however, official educational requirements locally or nationally have not been established.
- While the majority of SRC’s resolve within 7 days to 4 weeks, those with a complicated course or prolonged recovery may require a multidisciplinary healthcare team with expertise in concussion management.
Definition of Sports Related Concussion

• The Concussion in Sport Group (CISG) definition of concussion has not changed.
• The clinical signs and symptoms of concussion cannot be otherwise explained by drug, alcohol, medication use, or other injuries (such as cervical injuries or peripheral vestibular dysfunction) or other co-morbidities (psychological or medical conditions).
• These are often confused for concussion by practitioners and must be reported to patients and their families.
Epidemiology

• There are 1.0-1.8 million SRCs per year in the 0-18 years age group with a subset of about 400,000 SRCs occurring in high school sports.
• Concussion rates in the USA are estimated and primarily reported by surveillance systems looking at small samples of organized college or high school sports. There is little to no data concerning organized recreational, travel, or club sports or for everyday activities such as bicycling, skiing, snowboarding, skateboarding, the fighting arts. There is little to no data for youth/early adolescent athletes in sport.
• 50% of concussions in high school-aged adolescents are not related to organized sports and only 20% are related to organized school team sports.
• 2% and 15% of athletes engaged in organized sports will suffer a concussion during a specific season.
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<tr>
<th>Author</th>
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### Table 2
**Seasonal risk of concussion in sports**

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<th>Bretzin <em>et al</em></th>
<th>High school athletes in 15 sports</th>
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<td>(2015–2016)</td>
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**Total**

|       |       |       |     | 239,564 | 6,293 | 2.6 |

- *Total number of athletes estimated using 105 athletes per year on football roster.
- NCAA, National Collegiate Athletic Association.
Diagnosis of Concussion

• Diagnosis is often hampered by the lack of validated, objective diagnostic tests, the reliance on athlete self-reported symptoms, and co-morbid symptoms from other associated medical conditions such as mood disorders.

• In addition, symptoms often are delayed in onset, or at first, not recognized by the athlete.
Concussion in Preseason

• Preparation should include the Pre-participation physical evaluation (PPE) and the creation and practice of an emergency action plan (EAP).
• The athlete’s concussion history or that of other traumatic brain injury (TBI) including the number, recovery course and time between injuries, as well as the existence of other premorbid/comorbid conditions or modifiers of concussion should be documented.
• Learning disorder, attention deficit disorder, motion sickness or sensitivity, mood disorders or a personal or family history of migraine headaches, disorders of visual or auditory processing, and information on current medication and supplement use should be documented.
Preseason Baseline Testing

• The use of computerized neuropsychological (CNP) testing remains controversial.

• There is considerable normal variation in test performance with repeat testing in non-injured athletes; many tests are assessed a cost and continue to increase, and in younger athletes with continued neural development it is unknown when is the ideal interval to repeat baseline testing and what are the age-related differences in test performance.

• The NCAA considers “best practices” to include an initial baseline evaluation including a symptom checklist, cognitive evaluation and balance assessment. It does not require repeat annual baseline testing after an initial baseline evaluation for collegiate athletes.

• Baseline testing while useful in some cases, but is not necessary, required or an accepted standard of care for the appropriate management of SRC in all cases.
Sideline Assessment

• Reasons for immediate removal from play include loss of consciousness (LOC), impact seizure, tonic posturing, gross motor instability, confusion or amnesia, or suspicion of organic brain injury.

• Serious head injury may be suspected with prolonged LOC, severe or worsening headache, repeated vomiting, declining mental status, focal neurological deficit or suspicion of significant cervical spine injury.
Sideline Assessment

- Healthcare professional familiar with the athlete personality and co-morbidities.
- Testing should be performed in a distraction-free environment with adequate time for examination and administration of concussion tests.
- Sport-specific rules may not allow adequate time for evaluation. Consideration should be given to modifying these rules by the governing bodies of sports with inadequate evaluation times.
- Video Review is showing some utility.
Sideline Assessment

• The test-retest reliability of commonly used sideline concussion evaluation tests is below the generally accepted norms for clinical utility (0.75-0.90).

• Several concussion tests have a learning effect that must be factored into test review with repeated administration of the test.

• There is evidence that combining tests of different functions to form a multimodal assessment increases sensitivity and specificity for appropriate diagnosis of concussion.
### Table 3
Psychometric properties of sideline assessment tests*

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<tr>
<th>Author</th>
<th>Type of athletes</th>
<th>Athletes (n)</th>
<th>Concussed</th>
<th>Controls</th>
<th>Test and/or criterion</th>
<th>Sensitivity (%)</th>
<th>Specificity (%)</th>
<th>Test–retest reliability</th>
<th>AUC</th>
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Clinical reaction time (dropped weighted stick)

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<td>Eckner(^{123})</td>
<td>College football, wrestling, women’s soccer</td>
<td>102</td>
<td></td>
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<tr>
<td>Eckner et al.(^{47})</td>
<td>High school and college athletes</td>
<td>28</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Broglio et al.(^{33})</td>
<td>College athletes</td>
<td>261</td>
<td></td>
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</tbody>
</table>

\(^{†}\) Signifies statistical significance.
Sideline Assessment

• While athlete symptoms are the most sensitive indicator of SRC, the reliability of athlete-reported symptoms depends on accurate reporting.

• Symptom reliability may be affected by lack of recognition of the signs and symptoms of concussion or conscious false reporting to avoid loss of playing time.

• The primary role and conclusion for sideline assessment is to determine whether there is the presence of a SRC or not.
Office/Subacute Assessment

• A comprehensive history and neurological examination should be performed including details of injury mechanism, symptom trajectory, neurocognitive functioning, sleep/wake disturbance, ocular function, vestibular function, mood disorder, gait, balance and a cervical spine exam.

• The utility of sideline neurocognitive and balance assessments used to initially diagnose concussion decreases as early as 3 days after injury.

• SRC is confirmed by a clear mechanism consistent with concussion; characteristic signs, symptoms and time course of concussion; and no other co-morbidities responsible for clinical findings. It is not unusual for symptoms, signs and testing to resolve by the time of initial office visit.
Office/Subacute Assessment

• Elements of a complete examination include cervical spine evaluation, screenings for psychosocial or mental health disorders, and testing looking at the vestibular and oculomotor systems to help determine etiology of symptoms.

• Vestibular symptoms occur in 67% -77% of patients while ocular symptoms occur in approximately 45% of SRC.
Emerging Sideline Concussion Evaluation Tools

• The role of formal VOMS testing on the sideline has not yet been studied though empiric use has been promising.
• Newer technologies such as iPad balance testing do not have sufficient research to recommend their definitive use.
Helmeted and Non-Helmeted Impact Monitors

- At present, sensors may not consistently record head impacts or forces transmitted to the brain.
- At this time, impact monitors are a research tool requiring additional study and are not validated for clinical use in the diagnosis or management of SRC.
Use of Biomarkers of Concussion (Imaging)

• Medical imaging is often of little utility in the diagnosis and treatment of SRC.
• MRI can be considered for atypical or prolonged recovery
Use of Biomarkers of Concussion (Fluids)

• Protein biomarkers of injury and recovery in more severe forms of civilian neurotrauma and traumatic brain injury have shown some promise; however, in recent systematic reviews, the overall level of evidence is low for using fluid biomarkers for diagnosis of SRC.

• The Federal Drug Administration (FDA) recently approved a two-protein brain trauma indicator with glial fibrillar acidic protein and ubiquitin carboxy-terminal hydrolase L1, while Europe is clinically using S100 calcium-binding protein. These show promise for ruling out intracranial bleeds and structural damage to reduce the use of CTs in the emergency room. At this time, none of these tests has a role in the diagnosis or treatment of SRC.
Use of Biomarkers of Concussion

• There is current recommendation for genetic testing in the evaluation and management of athletes with SRC.
• Additional research is needed to determine how genetic factors influence risk of injury, time course and recovery after SRC.
Clinical Profiles

• Although SRC may present with symptoms representing only one clinical profile, SRC usually presents with symptoms and impairment supporting multiple profiles.

• Clinical profiles may be more applicable to athletes with persistent symptoms.
Management of Concussion

• Adolescents and adults – typically return to preinjury levels of clinical function within 2 weeks
• Pre-adolescent athletes- return to preinjury levels of function within 4 weeks
• It is important to communicate the usual time course and outcome to patients and families to relieve the anxiety and set realistic expectations.
Predicting Recovery

- Depression and subacute headache are risk factors for symptoms persisting for >1 month.
- A preinjury history of mental health issues, particularly depression, appears to increase the risk for prolonged symptoms.
- Athletes with learning disabilities or attention deficit/hyperactivity disorder do not appear to be at risk for prolonged recovery.
- New data suggests that a lower symptom-limited heart rate threshold during graded exercise testing within a week of SRC in adolescents predicts a longer recovery time.
Prescribed Rest

• In human studies, strict rest after SRC slowed recovery and led to an increased chance of symptom prolongation.

• Consensus guidelines endorse 24-48 hours of symptom-limited cognitive and physical rest followed by a gradual increase in activity, staying below the threshold of symptom-exacerbation.
Activity and Exercise

• Exercise intolerance is an objective physiological sign of acute concussion that appears to reflect impaired autonomic function and control of cerebral blood flow.

• There is some preliminary evidence that subsymptom threshold exercise improves recovery in acute concussion, and early symptom-limited graded exercise testing appears to be safe in athletes.
Role of Nutraceuticals

• There is no evidence in human trials that nutraceuticals prevent or relieve symptoms in SRC.
• Supplements are not FDA-regulated and potential harm or contamination should be considered that may affect recovery or eligibility.
Persistent Post Concussive Symptoms

• The new preferred term is Persistent Post Concussive Symptoms (PPCS) which is defined as symptoms that persist beyond the expected recovery time course (>2 weeks in adults, >4 weeks in children).

• Persistent symptoms do not necessarily represent ongoing concussive injury to the brain. Often symptoms may be inappropriately or mistakenly attributed to concussion from pre-existing or co-morbid conditions in PPCS.
Exercise for Persistent Post Concussive Symptoms

• The Buffalo Concussion Exercise Treatment Protocol, a progressive subsymptom threshold aerobic exercise program based on systematically establishing the level of exercise tolerance on the Buffalo Concussion Treadmill Test, is the most studied controlled exercise program.
Return to Learn

• SRC can induce changes in attention, cognitive processing speed, learning, short-term memory and executive function that make learning difficult.

• A RTL program should be established to aid in return to the classroom ideally by a multi-disciplined team.

• The RTL program should be successfully completed before the execution of a RTP plan.
Facilitate communication and transition back to school.

- Notify school personnel after injury to prepare for return to school.
  - Obtain consent for communication between medical and school teams.

- Designate point person to monitor the student’s status related to academics, recovery and coping with injury, and communicate with medical team.
  - School health professional, guidance counsellor, administrator, athletic trainer.

- Develop plan for missed assignments and exams.

- Adjust schedule to accommodate reduced or modified attendance if needed.
<table>
<thead>
<tr>
<th>Classroom adjustments</th>
<th>School environment adjustments</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Breaks as needed during school day.</td>
<td>• Allow use of headphones/ear plugs to reduce noise sensitivity.</td>
</tr>
<tr>
<td>• Reduce inclass assignments and homework.</td>
<td>• Allow use of sunglasses/hat to reduce light sensitivity.</td>
</tr>
<tr>
<td>• Allow increased time for completion of assignments and</td>
<td>• Limit use of electronic screens or adjust screen settings,</td>
</tr>
<tr>
<td>testing.</td>
<td>including font size, as needed.</td>
</tr>
<tr>
<td>• Delay exams until student is adequately prepared and</td>
<td>• Allow student to leave class early to avoid crowded hallways.</td>
</tr>
<tr>
<td>symptoms do not interfere with testing.</td>
<td>• Avoid busy, crowded or noisy environments—music room, hallways,</td>
</tr>
<tr>
<td>• Allow testing in a separate, distraction-free environment.</td>
<td>lunch room, vocational classes, assemblies.</td>
</tr>
<tr>
<td>• Modify due dates or requirements for major projects.</td>
<td></td>
</tr>
<tr>
<td>• Provide preprinted notes or allow peer notetaker.</td>
<td></td>
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<tr>
<td>• Avoid high-risk or strenuous physical activity.</td>
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</tbody>
</table>
Return to Play

• RTP has not changed since the initial CISG’s Summary and Agreement Statement of the First International Conference on Concussion in Sport, Vienna 2001.

• Its use continues to be controversial, though recommended in consensus, for lack of scientific study and debate over consideration of combination of steps.
<table>
<thead>
<tr>
<th>Stage</th>
<th>Description</th>
<th>Objective</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Symptom-limited activity</td>
<td>Reintroduction of normal activities of daily living. Symptoms should not worsen with activity.</td>
</tr>
<tr>
<td>2</td>
<td>Light aerobic exercise</td>
<td>Walking, stationary biking, controlled activities that increase heart rate.</td>
</tr>
<tr>
<td>3</td>
<td>Sport-specific exercise</td>
<td>Running, skating or other sport-specific aerobic exercise avoiding risk of head impact.</td>
</tr>
<tr>
<td>4</td>
<td>Non-contact training drills</td>
<td>Sport-specific, non-contact training drills that involve increased coordination and thinking. Progressive introduction of resistance training.</td>
</tr>
<tr>
<td>5</td>
<td>Full contact practice</td>
<td>Return to normal training activities. Assess psychological readiness.</td>
</tr>
<tr>
<td>6</td>
<td>Return to sport</td>
<td></td>
</tr>
</tbody>
</table>
Return-to-sport progressions should be individualised based on the injury, athlete’s age, history and level of play, and the ability to provide close supervision during the return to activity, and progressions may vary between athletes. Each stage is generally 24 hours without return of concussion symptoms. Consider written clearance from a healthcare professional before return to sport as directed by local laws and regulations.
Return to Driving

• Driving is a complex process involving coordination of cognitive, visual and motor skills, as well as concentration, attention, visual perception, insight and memory, which can all be affected by SRC.

• There is little data concerning the risk of driving after SRC, but preliminary evidence suggests some impairment exists when SRC patients report they are asymptomatic.

• It should be remembered that the adolescent SRC population are often inexperienced drivers.
Short Term Risks of Continued Exposure After Concussion or Premature Return to Play

- Increased risk of repeat concussion
- Increased rate of musculoskeletal injury
- ‘Second Impact Syndrome’
- Symptom prolongation
Long-term Risks After Concussion: Mental Health Problems and Depression

• Mental health issues are common, multifactorial and often present independent of participation in contact or collision sport.

• Long term research on contact sport athletes that addresses multiple variables is needed to understand the long-term risks associated with mental health problems, specifically depression.
Chronic Traumatic Encephalopathy (CTE)

- The most widely described risk factor to date is extensive exposure to *both multiple concussions and repetitive head impacts*, but the threshold of necessary exposure is probably specific to the individual and subject to multiple modifying risk factors.

- Athletes and former athletes who present with neuropsychiatric signs and symptoms that have been attributed to CTE should be evaluated for potentially treatable comorbid conditions that share symptoms and should not be assumed to have CTE.
Repetitive Head Impacts

• Although sub-concussive impacts have been associated with CTE, the short-term and long-term effects of repetitive head impacts, similar to SRC, cannot be accurately characterized using current available technology.
Disqualification From Sport

• Considerations for retirement from sport include the length of concussion recovery (progressively longer time to achieve symptom resolution), development of concussion with less forceful impacts, increased severity of concussions, as well as the athlete’s readiness or apprehension regarding return to sport.

• Additional contradictions for continued participation may include behavioral changes, post-traumatic seizures, persistent neurological deficit or imaging findings suggesting co-morbid or other pathology.
Prevention

- Rule changes, enforcement of existing rules, technique changes, neck strengthening and equipment modifications have been the primary focus of prevention.
- There is moderate evidence that delaying the introduction of body checking in youth hockey reduces concussion rates.
- The effectiveness of rule changes in youth soccer and football to reduce concussion incidence is not clear; however, initial evidence is showing that practice modification (i.e. decreasing tackling to ground days) and changes in tackling technique may reduce injury.
- Some football helmet designs have improved the ability to absorb force, but it has not been proven if it will reduce concussion rates.
Future Research Directions

• Epidemiological studies are needed in younger athletes, recreational activities, non-traditional sports and non-school sponsored team sports (travel, club, recreational).

• Continued study of high school, college and professional athletes to better understand concussion rates, repetitive head impact exposure, mechanisms, recovery patterns, risk factors and the success of specific intervention and prevention strategies.
Future Research Directions

• Research regarding objective tests, including neuroimaging and fluid biomarkers, to determine their diagnostic and prognostic utility.
• Research regarding specific factors or modifiers that are associated with prolonged recovery.
• Investigation into the utility of clinical profiles/concussion domains for diagnosis and treatment of SRC.
• Research the role of nutraceuticals in the prevention and treatment of acute concussion and for those with prolonged symptoms.
Future Research Directions

• The role of aerobic exercise, physical therapy (treatment of associated injuries such as cervical, ocular, and vestibular abnormalities) and psychological therapy in the treatment of SRC.

• Advanced studies to increase understanding of neurobiological effects and recovery after SRC.

• Development of evidence–based return-to-learn and return-to-sport programs.
Future Research Directions

• Exploration of the potential long-term effects of SRC and repetitive sub-concussive impacts on neurological health via prospective longitudinal studies and laboratory research.

• The role of genetic susceptibility to acute and chronic effects of SRC and sub-concussive impacts.

• Further development and implementation of primary and secondary prevention measures.
2019 Concussion Clinical Pearls
Ocular Symptoms

• Ocular

  – Ability of ocular system to work appropriately

  – Are vergence and divergence, smooth pursuits, saccades, accommodation, convergence, vestibulo-ocular reflex (VOR) and visual motion sensitivity (VMS) appropriate?
Ocular Symptoms

• May be pre-existing

• Prescreening Questions:
  – When you read pre-concussion, do you skip words?
  – When you read pre-concussion, do you lose your place?
  – When you read pre-concussion, do you get eye strain or headaches?
  – When you read pre-concussion, if distracted, are you able to find your place again?
Optometric Conditions

• Optometric Issues
  – Convergence Insufficiency
    • Important for reading
    • Inability to use two eyes together as a team
  – Oculomotor Dysfunction
    • Permits accurate visual scanning and exploration
    • Important for reading and copying from board
    • Inability for eyes to together track a moving target and switch fixation from one target to another
Optometric Conditions

• Optometric Issues
  – Accommodative Infacility
    • Important for academic efficiency and comfort to focus on an object – i.e. copy from blackboard
    • Inability to allow rapid and accurate shifts of attention from one distance to another with instantaneous clarity
    • Inability to allow student to maintain focus at reading distance
Optometric Conditions

• Optometric Issues
  – Visual Intake-Visual Memory
    • Allows for optimal academic and athletic performance as affects proficiency in reading comprehension and spelling
    • Inability to obtain maximum visual information in the shortest possible time
    • Inability to retain this information over an adequate period of time
Optometric Conditions

• Optometric Issues
  – Visual Motor Integration Deficit
    • Inability to analyze a visual stimulus, integrate that information with other systems, and produce a motor response (inappropriate eye-hand coordination)
    • Needed to produce written language
  – Fusional Instability
    • Inappropriate binocular function
    • Needed for near and distant visual tasks
    • Cause of blur or double vision
Ocular Recognition and Treatment

• Ocular
  – 42 to 69 % of patients report this
  – Frontal headache, tired behind eyes
  – Problems in math and science
  – End of day fatigue
  – See issues with near point convergence, accommodation, pursuits, saccades on VOMS
  – See decrease in verbal memory, visual motor speed composite and reaction time
  – Problem is in encoding not retrieval
Ocular Recognition and Treatment

• Ocular
  – Treatment
    • Vestibular Therapy
    • Vision Therapy – may have to do visual therapy before vestibular if extremely symptomatic
    • Exertion Therapy
    • ? Treatment for stress/anxiety
Mood Recognition and Treatment

• Anxiety and Depression may show itself in concussion course as early as within 7 to 10 days
• Regardless of comfort level, it is imperative to report these findings, along with physical findings, to parents/guardians to begin immediate treatment with psychology or psychiatry and set up realistic expectations as to complication on time course of recovery.
Mood Recognition and Treatment

• Anxiety/Mood
• Stress – see onset as quickly as 2 weeks and worsens with rest – highly underreported
  – immediate consideration of referral
  • Continued symptom inventory
  • Cannot turn off thoughts
  • Increased symptoms if think of symptoms
  • Refusal to attend social activities
  • Continued parental questioning of symptoms
  • Sleep problems are often co-morbid
Mood Recognition and Treatment

• Anxiety/Mood
• VOMS nil or mildly provocative – if vestibular overlay treat vestibular signs first
• Often see in presence of great ImPACT scores but high symptom complaints
Mood Recognition and Treatment

- Anxiety/Mood
- Treatment
  - Therapy (Cognitive Behavioral Therapy)
  - Exposure
  - Exertion
  - Behavior Regulation – diet, exercise, hydration, stress
  - Medications
    - SSRIs
    - Benzos
References


References

Thank You

The Underdog