CME

Office-Based Management of Pediatric and Adolescent Concussion

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CME EDUCATIONAL OBJECTIVES

1. Diagnose pediatric and adolescent concussion using directed clinical history and physical examination.
2. Identify specific associated premorbid conditions that increase risk of prolonged concussion recovery.
3. Implement timely prescription of physical and cognitive rest.

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During the past decade, there has been a tremendous amount of research that has provided an increased understanding of the underlying pathophysiology and far-reaching clinical implications of concussion as a form of traumatic brain injury. In addition, there has been a huge surge of interest in and awareness of concussions, in part due to high-profile cases involving professional athletes. These professional athletes, however, are merely the tip of the iceberg. An estimated 144,000 pediatric and adolescent patients are treated in emergency departments nationwide for concussion,[1] and this likely represents a significant underestimate of the actual incidence because many children do not seek emergency treatment for concussion. There are an estimated 3.8 million concussions due to sports annually[2] and the majority of these are in

TABLE 1.

Concussion Symptoms

Physical	Sleep	Thinking/Remembering	Mood Disruption
Headache	Sleeping more or less than usual.	Difficulty thinking or concentrating.	More emotional
Nausea	Drowsiness or fatigue.	Difficulty remembering.	Irritable
Vomiting	Trouble falling asleep.	Confusion	Sad
Balance		Feeling mentally foggy.	Nervous
Slowed reaction time		Feeling slowed down.	Depressed
Dizziness			
Sensitivity to light			
Sensitivity to sound			
Fuzzy or blurry vision			

Source: Adapted from Pardini et al[10]

the pediatric and adolescent populations.

In our own large pediatric network, our pediatricians see more than 1,500 concussions annually, which is a 300% increase in the last 4 years. In this context, the role of the primary care pediatrician in the diagnosis and management of concussion becomes essential.

THE ROLE OF THE PRIMARY CARE PEDIATRICIAN

The initial point of contact for many patients after sustaining a concussion is their primary care pediatrician. Patients are often scheduled for evaluation soon after sustaining such an injury. The timely recognition and early institution of appropriate management of pediatric concussion in this setting is essential to improving clinical outcomes as the result of this mild traumatic brain injury (TBI).

There is, to date, no single diagnostic modality, either radiologic or neurocognitive, that can be wholly relied upon to determine if there is a concussion. Instead, clinicians must pull together the entire clinical picture by uncovering symptoms in the medical history known to be related to concussion, and by conducting a physical examination specifically targeted at identifying known deficits associated with concussion.

In addition, the initial management of concussion does not begin with complex pharmacologic therapeutics, but rather with cognitive and physical rest,[3] which is a simple yet vital step that pediatricians can readily implement in their offices.

CLINICAL HISTORY

As with most clinical entities, obtaining an accurate history is critical. In addition to the date of injury and the mechanism of injury, paying specific attention to symptoms referable to concussion is essential. Any injury that results in forces transmitted to the brain can result in concussion, whether they are direct forces to the head or blows to the body that indirectly transmit forces to the head. The latter occurs in whiplash injury where rotational acceleration forces result in concussion.[3]

Establishing an accurate date of injury starts the recovery clock so that the pediatrician can reference clinical progress and current symptomatology to that date. It is important in clinical follow-up to determine if the patient is recovering as would be expected in a typical concussion recovery pattern over the course of a few weeks or is taking the recovery trajectory of an atypical, slow-to-recover concussion, because management issues change in the prolonged concussion with symptoms lasting longer than 4 to 6 weeks.[4] Prospective grading of concussions is no longer performed since there are no clear prognostic factors identifiable at the outset that correlate with outcome. Grading systems have been foregone in favor of looking at time to recovery (less than 1 month vs. more than 1 month in pediatric and adolescent patients); this determination can only be made ex post facto.[3]

Even though only an estimated 10% to 20% of concussions involve loss of consciousness, the history of the acute injury should include an assessment of loss of consciousness, which has been associated with prolonged recovery in concussion in the pediatric population but not in adults.[2,5-8] Immediate headache or balance or visual problems may be evident right away, as well as nausea and vomiting. Dizziness at the time of injury appears to correspond with prolonged recovery.[9] It is important to recognize that concussion symptoms may initially appear mild and may worsen over the subsequent 24 to 48 hours after the injury, especially if cognitive and physical rest are not instituted. Referral for brain imaging is generally not indicated unless there is particular concern for a high-impact mechanism of injury, skull fracture, or acute intracranial hemorrhage in the hours immediately following the injury.

Specific Concussion-Related Symptoms

There are stereotypical symptoms associated with concussion. Directed ques-

tioning is necessary to obtain these details, as patients (or their families) often do not think to offer information about these symptoms in open-ended questioning. Common symptoms in concussion are generally divided into physical/somatic, cognitive/thinking/remembering, sleep, and emotional/mood disruption categories. Attention to each individual symptom on the checklist is important while obtaining the clinical history (see Table 1).

Relevant Comorbidities

In addition to a standard past medical history, a specific assessment of a prior history of comorbidities known to be associated with prolonged recovery from concussion should be undertaken. In particular, a personal or family history of attention-deficit/hyperactivity disorder (ADHD), dyslexia, learning disability, amblyopia/strabismus, or other reading or visual tracking disorders; mood disorders such as anxiety or depression; and migraine headaches should be obtained.

Prior history of concussion and timing relative to the current injury is also important because that is the greatest risk factor associated with increased risk for future concussion.[3] Often patients and families will report that this is the first diagnosed concussion but upon further reflection, recollection of previous episodes of brief concussion-like symptoms associated with head injury may identify previously undiagnosed concussions due to the short duration of symptoms that, in the past, were considered inconsequential, but which are now believed to be clinically relevant concussions.

PHYSICAL EXAMINATION DEFICITS

It is also vital that the physical examination target systems that are known to be commonly affected by concussion (see Table 2). In addition to a thorough head exam that checks for signs of trauma, and a neck exam that assesses range of motion or limitations thereof (neck spasm) or signs of cervical cord neurapraxia (positive Spurling's sign with traction on the cervical cord indicating a stinger or burner), a comprehensive neurologic examination is essential. Although perhaps not normally part of the general pediatrician's standard neurologic exam, particular attention should be paid to visual tracking, vestibulo-ocular reflexes, and balance and visual convergence. If the clinician does not actively seek out these physical examination deficits, they can be easily overlooked and the neurologic exam may appear "grossly normal." As the saying goes, "If you haven't seen a concussion recently, it probably has seen you."

TABLE 2.

Specific Physical Examination Deficits in Concussion

Physical Examination Elements	How to Perform Examination	Findings
Dysmetria	Finger-nose-finger with examiner's finger moving horizontally.	Slow reaction time, past-pointing.
Nystagmus	Examiner's finger moving horizontally progressively more rapidly, stopping centrally.	Unable to visually track, beats of nystagmus at center of visual field.
Smooth pursuits	Examiner's finger moving horizontally progressively more rapidly.	Unable to visually track, jerky jumpy movements, provokes symptoms such as headache, dizziness, eye fatigue, signs such as welling up with tears.
Saccades	Examiner's fingers held at shoulder-width and forehead-chin distance to test horizontally and vertically.	Unable to perform or can perform only a few repetitions before symptoms or signs provoked as above.
Gaze stability	Patient fixes gaze on examiner's thumb while nodding and then shaking head.	Unable to perform or can perform only a few repetitions before symptoms or signs provoked as above.
Convergence insufficiency	Patient takes a pen with letters and holds at arm's length and brings toward their nose until becomes blurry/double.	Letters become blurry or double at > 6 cm from the tip of nose.
Balance	Tandem heel-toe gait forward and backward with eyes open and closed.	Raises arms for stability or widens gait or has extreme truncal swaying without normal righting.

Source: Master CL, Grady MF

Cerebellar Coordination

Finger-nose-finger is helpful to assess if the patient is notably slow in reaction time and exhibits frank dysmetria with past-pointing during the assessment.

SIDEBAR.

Prescription for Cognitive Rest Until Symptoms Abate

- No school
- No homework
- No computer work
- No texting
- No video games
- No reading
- No television if it causes symptoms
- No activities that trigger or worsen symptoms

Source: Master CL, Grady MF

TABLE 3.

Return-to-Play Protocol

Stage	Activity	Objective
No activity	Complete physical rest.	Recovery
Light aerobic exercise	Walking, swimming, aerobic exercise up to 70% of maximum predicted heart rate, no resistance training.	Increase heart rate.
Sport-specific exercise	Sport-specific exercise such as skating and running drills; no head impacts.	Add movement.
Noncontact training drills	Progress to complex drills; add resistance training.	Exercise, coordination, add cognitive load.
Full contact practice	Normal practice after cleared by medical personnel.	Restore confidence and timing, allow assessment of functional skills.
Return to play	Normal game play.	Full return to play.

Source: Adapted from Consensus Statement on Concussion in Sport 3rd International Conference on Concussion in Sport held in Zurich, November 2008[3]

Vestibulo-Ocular System

Nystagmus is assessed by having the patient follow the examiner's finger laterally side to side, starting slowly and increasing in speed (and therefore, difficulty), stopping in the middle. The examiner can assess beats of nystagmus centrally (a few beats of nystagmus at the end-range of lateral visual tracking can be normal).

Smooth pursuits, which occur when visually tracking a moving object, are evaluated using the same technique as used for eliciting nystagmus. Observe if the patient is able to continue to track the examiner's finger as the speed increases. Many concussed patients become symptomatic with headache, dizziness, or eye fatigue and are unable to track the examiner's finger whether moving slowly or more rapidly; the eye may reflexively fill with tears as a result of the provocation. Injured patients may also have jerky and interrupted movements rather than smooth eye movements when attempting this maneuver.

Visual saccades are corrective eye movement that occurs during visual tracking. They are evaluated horizontally and vertically by having the patient hold his or her head still while looking back and forth between two stationary objects, such as the examiner's index fingers held at approximately shoulder-width apart for horizontal saccades, or at forehead and chin level for vertical saccades.

Again, this maneuver may cause tears to well up in patients with a concussion. There may also be slowing, interruption, or circular tracking rather than sharp, crisp horizontal and vertical saccades. Deficits in these areas correlate with difficulty reading, as well as looking up and down in school between a SMART board or computer screen and a notebook on a desk or a keyboard.

Gaze stability is the ability to hold a fixed visual picture while the head is moving and is assessed by having the patient nod his or her head vertically or shake it side to side while focused on a fixed object such as the examiner's thumb, to see if symptoms or physical tearing are elicited.

Convergence or accommodative insufficiency is often seen in concussion. It can be assessed by having the patient hold, at arm's length, a pen with letters on it and slowly bring it toward their nose while the examiner measures the point at which the letters becomes blurry or double. The normal range in children appears to be around 4 cm, but may be as low as 1 cm to 2 cm; the normal range in adults is approximately 4 cm to 6 cm.[11,12]

Balance Test

Balance can be tested in an efficient, dynamic, and functionally relevant manner by having the patient perform heel-toe tandem gait forward and backward with eyes open and closed. Each variation represents a slightly increased level of difficulty in maintaining balance for the concussed patient. Abnormalities may include mild truncal sway with difficulty righting, a wider-based gait, frank gait instability with arms raised up, or the inability to walk in a tandem fashion whatsoever.

CONCUSSION CARE PLAN

Physical and Cognitive Rest

Once the diagnosis of concussion has been confirmed, it is important that clinicians implement appropriate treatment for diagnosis in a timely manner. Expert opinion from Consensus Statement on Concussion in Sport 3rd International Conference on Concussion in Sport held in Zurich, Switzerland, in November 2008 includes recommendations for cognitive and physical rest immediately after sustaining an injury.[3] Much attention has been paid to the importance of physical

rest and graduated return to play, perhaps in part due to the high-profile nature of concussions in professional sports where play is the nature of the professional athlete's work. Relatively less attention has been paid to the concept and implementation of cognitive rest. In pediatric clinical practice, this turns out to be the lynchpin of concussion management in pediatric and adolescent patients, as school is essentially the "workplace" for children. Attempting to continue their normal cognitive workload while recovering from a brain injury can exacerbate and prolong symptoms and recovery.

Physical and cognitive rest is individualized, but for most student-athletes, strict initial cognitive rest after sustaining a concussion should include instructions for no school, no homework, no reading, no texting, and no video games until there is a decline in concussion symptoms and the patient feels asymptomatic (ie, no headache) while at physical and cognitive rest (see Sidebar). Permitted activities are those that do not trigger either immediate or delayed symptoms.

Certain activities such as listening to music or watching television may need to be individualized because these activities will trigger symptoms in some children, but not others. The key is to not participate in any activities that worsen symptoms and to cease any activities as soon as symptoms are exacerbated. Many families will report that the injured child sleeps excessively during the first 48 to 72 hours and this sleep appears to have a salutary effect on symptoms.

Role of Medications

During this recovery phase, medications for concussion symptoms are generally not recommended. Acetaminophen and ibuprofen have not been reported as very helpful with symptoms, and may mask symptoms, causing patients to over-exert themselves. Prolonged daily use of these medications also may result in rebound medication-associated headaches. Melatonin (3-6 mg), taken 1 hour before bedtime, is safe in this population and is a useful adjunct to help initiate sleep during this phase of recovery.[13] Amantadine has also been used for "fogginess" and attention issues, and it may provide benefit after a period of rest, although prospective clinical trials have yet to be conducted.[14]

Graduated Return-to-Learn and Return-to-Play

Once patients are headache-free for 24 hours, a controlled and slow ramp-up of cognitive activity is initiated. It is important to recognize that the patient's cognitive stamina is still not normal, and thus the patient will have difficulty tolerating the kind of prolonged cognitive activity required by school attendance and participation in school activities. At this stage, it is helpful to reintroduce cognitive activity for brief periods of time, just up to the point of triggering symptoms. When this threshold is reached, the patient stops the activity for a cognitive break until symptoms return to baseline.

Further delineation of this portion of the Concussion Care Plan is included in the companion article in this issue, "The Importance of 'Return-to-Learn' in Pediatric and Adolescent Concussion".

Once student-athletes can tolerate a full day at school, a full schoolwork load without symptoms, and are caught up in school, initiation of a formal return-to-play protocol may commence. Prior to this, light activity that does not trigger symptoms is permitted. The Zurich Consensus Statement from 2008 contains the definitive return-to-play protocol that is the model for return to play across the country and around the world (see Table 3).[3]

REHABILITATION AND REFERRAL IN CONCUSSIONS WITH PROLONGED RECOVERY

This concussion care plan is intended for the management of a straightforward concussion that exhibits a dramatic response to cognitive rest within a few days, with a successful controlled ramp-up of cognitive and physical activities over the course of a few days or weeks. Patients who continue to have acute intractable symptoms despite cognitive and physical rest or who are unable to ramp-up their cognitive or physical activities by 3 to 4 weeks post-injury may need referral to a specialist with experience in managing concussions with prolonged recovery time. Further evaluation and management may include educational, rehabilitative, and neuropsychological interventions.

CONCLUSION

It is important that pediatricians have the knowledge and skill set to recognize and diagnose pediatric and adolescent concussion, as it is a growing problem seen in primary care offices. Appropriate, prompt diagnosis and management of an acute concussion with cognitive and physical rest can result in the timely resolution of symptoms. This, followed by a controlled ramp-up of cognitive and physical activity, may prevent straightforward concussions from becoming prolonged-recovery concussions requiring further medical, educational, and rehabilitative interventions as a result of delayed diagnosis and treatment, resulting in prolonged post-concussive symptoms. ■

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