PedsCases Podcast Scripts

This podcast can be accessed at www.pedscases.com, Apple Podcasting, Spotify, or your favourite podcasting app.

Persistent Post-Concussion Symptoms

Developed by Adam Neufeld, Brendan Lee, and Dr. Kowalczyk for PedsCases.com.
October 31, 2020.

Introduction:

Hello and welcome to this PedsCases podcast on persistent post-concussion symptoms which is part 2 of our 2-part series on concussions. This is Adam Neufeld & Brendan Lee, and we are medical students at the University of Saskatchewan. A special thank you goes out to our supervisor Dr. Kowalczyk, who is a pediatrician with expertise in sport-related concussion.

Although concussion research is plentiful and the topic well researched, complex cases of concussion can be difficult to evaluate and manage, especially when patients develop persistent symptoms following a concussion. Although there are many interchangeable terms for this, we will use “Persistent Post Concussion Symptoms” or “PPCS” throughout. As PPCS is still not well understood, and definitions and studies in the literature are variable and mixed, our aim here is to provide some clarity around this complex topic, and an effective clinical approach to help manage PPCS. To do this, we will focus on several large and high quality review papers to date, including studies by Makdissi et al. (2013) & Eisenberg et al. (2013) and the Berlin International Consensus Statement on concussion in sport (see (McCrory et al., 2017; Davis et al., 2018).

The objectives for this podcast are:

1. Define PPCS and some epidemiology
2. Review risk factors for developing PPCS
3. Discuss an approach to evaluating patients with PPCS
4. Cover a general approach to management of PPCS
5. Outline a focused approach to the assessment and management of specific persistent post-concussion symptoms

As usual, before we get into each of these objectives, let’s start with a case.

CASE:

A 12-year old boy named Bobby presented to his primary care physician a few days after sustaining a head injury while snowboarding. While attempting a jump in the snowboard park, he fell back hitting his back and head. He was wearing a helmet and

did not lose consciousness following the injury. He reported whiplash, mild confusion and feeling "shaken up" immediately afterward. Despite feeling unwell, he continued to snowboard for the rest of the day. When he woke up the next morning, though, he had a bad headache, felt nauseated, and had sensitivity to both light and sound. Using his phone was particularly bothersome and lights were making him feel nauseous.

Bobby's past medical history was significant for 3 prior concussions. His family physician diagnosed him with a concussion and recommended some rest. After taking a week off from school, Bobby tried to return to regular classroom activities, but unfortunately, his symptoms were not improving like they had following his prior concussions, and he needed to take more time off from school.

Weeks passed by but things were not improving, and in fact, some symptoms were worsening. Exercise, reading, lights, sounds…these caused Bobby to have a "constant migraine." He was also experiencing tinnitus. He tried to remove all electronics and spend time in the dark, to give his eyes and brain some rest, but it was not really helping. Eventually, a neurologist was consulted and a CT and MRI were ordered—both were unremarkable. After several months off from school and little to no signs of improvement, Bobby had to take a leave from school, with plans to restart the following year. After three months of continuing symptoms, he was diagnosed with persistent post concussive symptoms.

1. Define persistent post-concussion symptoms

To quickly review…concussions are a type of brain injury that are caused by rotational acceleration of the brain, following an impact directly to the head or to another part of the body. For example, you can sustain a concussion after being hit on the shoulder! Concussions are considered a "functional" injury, in that advanced imaging (such as a head CT or MRI) are almost always unremarkable. What makes diagnosis difficult is that the patient-reported cognitive, physical, and affective symptoms are often non-specific, and other health conditions (e.g. depression) can present similarly. This makes the diagnosis of concussion easy to miss, especially if the injury is more subtle and symptoms are mild or delayed.

Generally speaking, once a concussion is properly diagnosed, and management is initiated, most youth and adolescents completely recover and report resolution of symptoms within 4 weeks. Most of these injuries are shown to occur to kids between the ages of 10-14. Counterintuitively, adults actually tend to recover faster, reporting symptom resolution in about half that time. However, emerging research is now showing that between 10 and 30% of youth will take longer than 4 weeks to recover. According to the 2017 Berlin expert consensus, this is when the term 'persistent symptoms' should be used. For adults, they proposed a lower cut-off of 10-14 days. We acknowledge that there is much controversy surrounding the definition of persistent post-concussion symptoms (or PPCS), but in keeping with the Berlin statement and the Ontario Concussion Guidelines, we will use the 4-week definition throughout this podcast.

Now, you may be wondering why some patients take longer to recover than others? Indeed, many hypotheses have been proposed to explain why this might happen, and although the pathophysiology is still poorly understood, we now recognize that a patients' persistent symptoms may be due to an ongoing physiological injury to the brain; either due to a primary persistent change in brain function, a secondary process (like dysfunction in mood, cranial nerve, vestibular, or oculomotor function), or, more likely, a combination...More on this to come. Let's move onto our next objective.

2. Risk factors for PPCS

Moving onto our second objective, we will now review known risk factors for persistent symptoms following a concussive brain injury. There is still much uncertainty around this topic, and in general, the literature is complex, mixed, and at times difficult to interpret. In an attempt to provide some clarity and settle what the data indicates is contributory, we summarize here, the results of a large systematic review by Iverson et al (2017). This paper synthesized all relevant published studies to date, including 240 PDFs, 101 peer-reviewed journal articles, and 13 abstracts, from the Berlin Concussion in Sport Conference experts. The main risk factors that will be covered are: age, gender, prior concussion (with or without prolonged recovery), incomplete recovery from prior concussion with re-injury, pre-injury mental health problems, degree of acute or subacute symptom burden, vestibulo-oculo-motor dysfunction, and migraines.

In terms of age, it is pretty widely accepted that age is a significant risk factor for developing PPCS, with adolescents being at the highest risk, especially during high school. Though there are myriad common-sense reasons for this to occur (e.g. risk taking, peer pressure, activity level, etc.), as you'll see, there are other less obvious, predisposing factors which may contribute to their risk for PPCS, as well.

For gender, females are consistently reported to take longer to recover from concussions than males and are more likely to have symptoms that persist for more than a month. Proposed hypotheses for why include variations in neck strength, injury biomechanics, and overall injury rates. In addition, females, as a group, tend to report more symptoms than males, both before and after sustaining an injury. The reported rates of prolonged post-concussion symptoms among men may therefore be underreported.

Perhaps unsurprisingly, several large scale studies have associated prior concussion with higher risk for future concussion and multiple concussions with greater symptom severity and prolonged recovery. As such, despite the overall evidence that suggests prior history is not a high quality predictor of clinical outcome, it is generally accepted, on average, that prior concussion history is a risk. By "on average", we refer to the fact that, for an individual athlete, the symptoms they incur from their second concussion may actually cause less severe symptoms and be associated with a shorter recovery than their first head injury. But, when taken collectively, it is clear that athletes who sustain prior concussions generally experience worse symptoms, longer recovery times, and lower brain function, than athletes who have only sustained one.

What complicates matters a bit is that prior concussions have been associated with more pre-injury symptom reporting. While it is true that athletes who sustain prior concussions are more likely to have a prolonged recovery or period of symptoms compared to athletes with only one prior concussion, it is important to note this is not consistently the case, and sometimes re-injury manifests with milder symptoms. For example, sometimes athletes can have their first concussion symptoms last 5 or more weeks, whereas their second one lasts a mere 3 days. Clinically, a range of acute and subacute post-concussive symptoms have been shown to help predict outcomes after concussion, which include severity of cognitive deficits, headaches, dizziness symptoms, oculomotor dysfunction, and depressive symptoms. There have been inconsistent findings regarding whether specific injury severity characteristics (e.g. LOC, retrograde amnesia, post-traumatic amnesia) are predictors of prolonged recovery following concussion.

Previous studies have found that genetics, sex differences, younger age, neurodevelopmental conditions like ADHD or learning disability, personal and/or family history of migraines as well as mental health problems might also potentially contribute. The difficulty in interpreting findings from these studies, however, is that research designs have largely been diverse (e.g. retrospective, prospective, case-control, cohort, and epidemiological), many different clinical outcomes have been measured (e.g. symptoms, cognition, balance, return to school and return to sports), and there is considerable variability in when and how outcomes were measured.

In terms of neurodevelopmental problems, kids with issues like ADHD have been shown to have a higher lifetime incidence of concussion and report more concussion-like symptoms in their daily lives, in the absence of injury. However, in general, the available evidence does not suggest they are at greater risk for worse outcomes or slower recovery than anyone else. In terms of pre-injury mental health problems, particularly depression is considered a risk factor for prolonged recovery in a small number of studies.

For headaches, a pre-injury history of migraines was not related to outcomes in most studies, but it was related in one large multi-centre, prospective study. A problem with many studies assessing headache and clinical recovery is their use of self-report questionnaires, which are often difficult for patients, in terms of determining the difference between “headache” and “migraine.” This could contribute to the mixed findings in the literature. Put together, having a history of migraine might promote increased risk for slower recovery, but more evidence and research is required to establish this correlation.

There is a longstanding interest in connecting injury symptoms and severity (e.g. LOC, retrograde or post-traumatic amnesia) with clinical outcomes. Again, the literature is mixed regarding these variable factors. Fact is, most concussions do not have loss of consciousness, and LOC itself is not a strong predictor of outcome in most studies. It is therefore considered a weak predictor. Post-traumatic amnesia was not related to clinical outcome in most studies either. Retrograde amnesia has more consistently been

correlated with short-term outcomes, but few studies show an association between retrograde amnesia and slower recovery time. The consensus is that the initial injury severity indicators are likely less important than the early clinical consequences (e.g. symptom burden) of the injury. Many studies have shown that greater severity of acute and subacute symptoms are associated with slower recovery, and a small number of studies indicate that greater acute cognitive deficits go along with that.

In summary, the strongest and most consistent predictor of slower recovery following concussion is greater severity of a person's acute and subacute symptoms following the injury. Having a low-level of symptoms in the first several days following an injury is a generally favourable prognostic indicator. The development of subacute problems like headaches, or depression, are likely risk factors for more persistent symptoms lasting greater than a month. Kids and young adults, especially those with a pre-injury history of mental health and/or migraine history, appear to be at somewhat of a greater risk for slower recovery. Those with ADHD and/or learning disabilities do not appear to be at greater risk, although they may require more care in planning for return to school or sports. The teenage years, particularly high school, seems to be the time when individuals are most vulnerable to having persistent symptoms, with greater risk for females compared to males.

CASE REVISITED:
Going back to our case, Bobby did not have a history of depression or anxiety; however, he did have a history of risk-taking with three previous concussions and a positive family history for migraine. After enduring symptoms for >3 months, Bobby was shocked and frustrated with the speed of his recovery, especially since it only took him several days to recover from his previous concussions. The stagnancy of his symptoms began to wear on him and he became increasingly sad and anxious. He worried he would never fully recover and couldn't stop thinking about all he was missing out on. He began isolating himself and started having trouble sleeping. His family and friends became increasingly concerned about Bobby's health and well-being and recommended seeking treatment for a formal evaluation.

Next, let's discuss what that evaluation should look like in practice.

3. Outline a general approach to the evaluation of PPCS
When faced with a patient experiencing PPCS, the first step is to obtain a thorough history and focused physical examination. Clinical findings should then guide any additional investigations. The clinician should formulate a differential diagnosis, consider other coexisting and/or confounding processes, and not overlook confounding or secondary contributing processes. These include injury to peripheral nervous system (e.g. occipital nerve), to peripheral structures (e.g. neck or inner ear), the development of secondary headache syndrome and/or lowering of threshold to experience severe headaches (e.g. migraines), development of mood disorders such as anxiety or depression, and their secondary consequences, such as missing school and falling behind. Also, important to consider is the effects of treatment, which will require being away from solo or team sports and exercise, and being away from friends, which can

potentiate depressed mood. Lastly, it is less common but important to consider malingering and secondary gains, such as school accommodations, being away from sports they do not enjoy, getting more attention from others, and spending more time with family or friends they enjoy.

Next we would like to point out a few key historical and physical exam points that we recommend exploring.

History:
There are 5 main groups of symptoms that should be inquired about during the history portion of the assessment. They include:

- Physical/somatic: including headaches and neck pain
- Vestibular such as hearing, tinnitus, and balance
- Emotional such as feelings of anxiety, low mood, and suicidality
- Cognitive, such as focus, attention, and memory
- Sleep, such as insomnia, prolonged sleep, or nightmares

A pre-visit questionnaire can be administered with these symptoms to facilitate the process and direct the clinical visit, and the questionnaire can then be administered over subsequent visits, as a tool for monitoring the patient's recovery.

Physical exam:
The focused physical exam should include:

- Assessment of the patient's general appearance and neurological status
- A full neurological exam
- Neck exam (including palpation in the suboccipital area, range of motion, and Spurling's test)
- Specific assessment of oculomotor function
- Balance evaluation
- Dix-Hallpike maneuvers, in those patients presenting with dizziness

Investigations:
Investigations that may be considered based on clinical findings include:

- Neuropsychiatric testing for patients who demonstrate functional impairment
- Advanced brain imaging - CT, MRI for patients who complain of severe and acute headache, visual changes, or loss of consciousness, when there is concern for intracranial hemorrhage.
- Buffalo Concussion treadmill test to determine a patient's exercise tolerance and degree of physiological changes on symptoms and establish a baseline for increasing activity.
- Anxiety and depression rating scales such as SCARED, PHQ9, for patients who demonstrate changes in affect or have concerns about mood; especially when there is concern for isolation and/or thoughts of self-harm or suicide.

Involvement of other specialists:
Patients who are significantly affected can best be served at a multidisciplinary concussion clinic. The exact type of specialist who make up the team will vary slightly by institution, but may include sports medicine physicians, neurologists, ENT doctors, ophthalmologists and/or optometrists, physical therapists, psychologists including neuropsychology, psychiatrists (or other physicians who are comfortable evaluating and treating mental health problems).

4. Outline a general approach to the management of PPCS
As the management of PPCS can be difficult, it can be optimized by using a collaborative care treatment model (i.e. with a multidisciplinary team approach), which largely focuses on identifying and treating coexisting and confounding processes, mentioned previously. Often, it will involve addressing specific symptoms (e.g. headaches, depression) with targeted therapies, encouraging exercise (specifically – sub-symptom threshold aerobic exercise), supporting return to school, and educating patients and families. Pharmacological interventions, such as oral medications and peripheral nerve blocks are sometimes considered as well.

That said, concussion management, and which specialists to involve, somewhat depends on where the patient is on their journey to recovery. This can be broken down into 4 main phases: baseline, acute, subacute, and prolonged, where acute symptoms show up immediately following the concussion, and subacute ones start after the acute phase, continuing until 4 weeks post-injury. As the focus of this podcast is prolonged symptoms, we will focus on management of youth with subacute and prolonged symptoms beyond 1 month.

Management of concussions among youth in the subacute phase (which is from the first few days to the first 4 weeks) is critical, because approach during this time period (particularly with regards to rest) may be very important in preventing prolonged symptoms. Although physical and cognitive rest is beneficial in the first few days after injury, there is also emerging evidence to suggest that continuing to restrict activity can result in a longer recovery. It is therefore recommended that students return to their schoolwork gradually, after a few days of rest, and be offered academic accommodations, such as decreased course/study load. Encouraging light physical activity that does not exacerbate their symptoms (also known as sub-symptom threshold aerobic exercise) may also be beneficial to recovery. It is important to avoid activities that can place the patient at increased risk of additional significant head trauma, as these can prolong recovery. In this context, we mention briefly the controversial “second-impact syndrome” (SIS). SIS is described in the literature to be the uncontrolled swelling of the brain that arises in the context of a second concussion before symptoms of the first concussion have subsided and can have fatal consequences due to herniation. A warning however, that there is much debate in the literature around SIS.

Let’s move on now, to specific symptoms, and how we might address them.

5. Outline a focused approach to the assessment and management of specific persistent post-concussion symptoms

Now, we will outline a focused approach to the assessment and management of the most commonly reported symptoms by youth experiencing a prolonged recovery. Specifically, we will discuss:

- headaches (+/- neck pain),
- vestibular dysfunction,
- emotional symptoms,
- cognitive impairment, and
- sleep disturbances.

It is important to keep in mind that these should not be addressed in isolation, as much overlap can occur. For example, poor sleep can trigger and/or worsen headaches. Hence, a multidisciplinary approach is best when managing a patient with persistent post-concussion symptoms.

Assessment and management of headaches:

Persistent headaches are one of the most common complaints of children and adolescents who have a prolonged recovery following a concussion, and unfortunately, evidence based treatments are sparse and the current management approach is primarily based on clinical experience. As such, questions to characterize the pain (e.g. location, character, alleviating factors, worsening factors, timing, etc.) should be asked. Patients should also be asked about red flag symptoms (such as headache of sudden onset, presyncope or LOC, headaches that wake them from sleep or worsen with position, or have coexisting jaw claudication, or pain in the temporal, eye, and scalp distributions). These may suggest an alternative etiology, such as neck pain, occipital neuralgia, secondary migraine disorder, anxiety, poor sleep, acute vascular events, mass or bleed, inflammatory conditions (e.g. temporal arteritis), infection (e.g. meningitis), and glaucoma, among others. Patients should also be asked about any pre-injury headache history (which again is a risk factor for increased symptoms following concussion). Any neck pain should also be documented, as this can lead to secondary headaches.

In terms of management, lifestyle interventions typically pose minimal risk and should be offered as a first-line intervention, and continually reviewed and encouraged. These include sleep hygiene, regular meals, limiting caffeine and alcohol, and stress management. Sub-symptom exercise should also be encouraged, as emerging studies are demonstrating significant benefits on recovery. Physical therapy is supported by emerging studies, particularly for patients with coexisting cervical spine and/or vestibular symptoms, and especially for neck muscle strains and pain, for which massage therapy can also be useful.

Now, for abortive medications (e.g. acetaminophen, ibuprofen, naproxen, and triptans), these can actually worsen headaches! As such, use should be regularly reviewed, modified, or in some cases, completely discontinued, and patients should be counselled on limiting their use. There are numerous prophylactic medications that are used, such

as amitriptyline, topiramate, propranolol, and others. However, there is no good evidence that exists at this time which demonstrates benefits. Moreover, a recent RCT study examining the use of these kinds of medications in children with chronic migraines found them to be no more effective than placebo. Interestingly, magnesium and vitamin B12 supplementation has been found to be beneficial for some patients with chronic headaches. Given their low risks, vitamin B12 and magnesium should generally be offered.

For patients with headaches that are suspected to be secondary to peripheral nerve injury, such as occipital neuralgia, peripheral nerve blocks may be beneficial. In a retrospective chart review, among 15 pediatric patients who received an occipital nerve block for PPCS, 64% of them reported an improvement in their quality of life and demonstrated reduced symptom scores.

Assessment and management of vestibular dysfunction

After headaches, dizziness is the second most commonly reported symptom, following a concussion. Hence, it is important for clinicians caring for concussed youth to have a good understanding of the vestibular system and vestibular disorders that may arise following head injury. The vestibular system is a complex integrated network of structures responsible for maintaining postural control and balance. Important structures include the inner ear vestibular organs, the vestibular nerve, brainstem, and the reflex pathways that stabilize vision, head, neck, and body during movement. These reflexes are known as the vestibulo-ocular reflex (which stabilizes vision with head movement), vestibulospinal reflex (which stabilizes the body), and the vestibulo-colic reflex (stabilizes the head/neck). Disruption of any of these structures following a concussion can trigger a variety of symptoms, including vertigo, poor balance, vision problems and reading difficulties. In certain patients, these symptoms can be partially, or even entirely psychological in nature.

History obtained from patients with vestibular complaints should identify and characterize specific symptoms - just like with a pain history. Questions to ask include timing (such as whether symptoms are intermittent, persistent, and the duration), triggers, aggravating or alleviating factors, and any associated symptoms (such as nausea, headaches, tinnitus, hearing impairment, and the severity). This information can provide clues to the etiology. For example, episodic dizziness associated with migraine symptoms such as headaches, photophobia, and phonophobia suggests a vestibular migraine. Conversely, very brief episodic vertigo provoked by head movements (such as rolling in bed) suggests benign paroxysmal positional vertigo (BPPV), which is actually one of the most common identifiable causes of dizziness after a concussion. BPPV is an inner ear problem, in which the calcium carbonate crystals that are normally located in the utricle of the inner ear become displaced into the semicircular canals.

Physical examination of patients with vestibular complaints should include a neurological examination, as well as assessment of balance and oculomotor function. There are several assessment tools that are easy to administer and can be used in the

office. Two examples include “Balance Error Scoring System” (BESS) and “Vestibular Ocular Motor Screening” (VOMS). The Dix-Hallpike maneuver can also be a useful tool, as mentioned, as well as Canalith repositioning maneuvers, which is another treatment modality that involves a similar aim of displacing otoliths. Rather than cover these in detail, we simply provide their names here, for your reference. Patients should be counseled that sometimes a few attempts are needed.

Thankfully, the majority of vestibular symptoms after a concussion are brief, and self-limiting, except for migraine vertigo or patients with oculomotor deficits or difficulties reading, in which therapy may be required. In general, vestibular symptoms can be managed effectively with counseling and encouragement to return to normal daily activities as tolerated. However, for patients with persistent vestibular symptoms following a concussion, formalized vestibular rehabilitation therapy (VRT) should be considered. This is a specific type of physical therapy designed to desensitize the vestibular system using a variety of balance and symptom-provoking exercises, which has been shown to have high success rates in patients with chronic symptoms. Unfortunately, there is still no good evidence regarding the timing of VRT, but some emerging evidence suggests that earlier may improve recovery.

Patients who are not improving as expected should first be reassessed to look for other etiologies and/or confounding factors. Referral to ENT should also be considered where audiometry and more advanced vestibular diagnostic testing can be performed. Advanced brain imaging should be pursued if there is concern for central nervous system disorder, which may or may not be related to the concussion (Examples: Chiari malformation, cerebellar infarction). These patients will often have other signs and symptoms on history and physical, such as occipital headaches, inability to walk without falling, focal neurological findings, and/or nystagmus that cannot be suppressed with visual fixation. Imaging should also be considered for patients who are not responding to treatment.

Emotional Symptoms

Mood symptoms following a concussion, such as sadness or anxiety, are common in children and adolescents with prolonged recoveries. They are thought to arise from the head injury itself, and/or be the sequelae of activity restrictions and limitations that come with concussions. They can be a new onset, or exacerbations of pre-existing mood disorders. A study by McCarty et al (2016) reported that 40% of pediatric patients (age 11-17) with persistent symptoms (>1 month) had high depressive symptom scores. They suggest medications such as SSRIs (selective serotonin reuptake inhibitors) may therefore be appropriate and beneficial in as many as 1 in every 3 pediatric patients with a prolonged recovery, after an appropriate assessment. Hence, early and ongoing screening for mood symptoms and disorders is very important in children recovering from a concussion. This can be done during the primary care visit with a good history. Again, rating scales can also provide additional information, as mentioned.

Unfortunately, for scales to use, there are currently no available guidelines. But, consideration can be made regarding the PHQ-9 for depression, the SCARED screen for anxiety, and the SNAP/VANDERBILT screen for ADHD. Relatedly, sleep is an

equally important component to assess as part of this screening, wherein it is recommended to ask about: number of hours, insomnia, hypersomnia, sleep hygiene in general, and how daily function is being affected (school, homework, relationships with friends and family).

As we have seen, the number of affected youth is quite high, and once recognized, appropriate management can significantly affect outcomes. Treatment plans are individualized and based on patient preference and severity. They can consist of therapy, medications, or a combination of both. Cognitive behavioral therapy (CBT) is a specific type of therapy that has been found to be very effective in the treatment of anxiety and should be offered to patients with a significant anxiety burden. Basic skill training such as sleep hygiene and relaxation techniques can also be provided during primary care visits. With regards to medications, many of the ones used to treat anxiety, such as SSRI's, can also be used to treat depression. Ultimately, when care can be delivered using a collaborative care model, there tends to be greater improvement in mood symptoms, overall post-concussive symptoms, quality of life, and patient satisfaction. Close follow-up of patients is important to monitor progress and address any new needs that may arise. A reminder that providers should always inquire about suicidal ideation.

Cognitive Impairment

Cognitive complaints such as difficulties with memory and concentration are commonly reported after concussive brain injury. Although these are typically short-lived and self-resolving in the majority of youth, in some cases, recovery can become prolonged. Moreover, emerging studies examining the long term sequelae of concussive brain injuries, suggest that for some individuals, these impairments can persist for years.

For assessing cognitive impairment, the focus should be on combining subjective patient reported symptoms, with an objective assessment, or tests. Besides physical exam components (e.g. Snellen chart, memory tests, etc.), other referrals may be required, for formal neuropsychiatric testing.

In terms of management, academic accommodations are often all students need in order to return to school and maintain similar academic success. However, if accommodations alone are not enough, medications that help improve concentration, memory, and mood of these patients can be considered. There are currently no medications that are approved specifically for concussion related cognitive issues. To date, methylphenidate (aka Ritalin) has been the most commonly studied treatment for cognitive symptoms. There is some evidence, including various RCT's, that support the use of methylphenidate for the treatment of cognitive symptoms following a concussion, primarily in the treatment of deficits in attention, speed processing, and/or for deficits in general cognitive functioning. Another drug, Amantadine, has also shown some promise in pediatric patients. For example, in a retrospective case-control study of 54 pediatric patients, it was found that Amantadine was safe and significantly improved cognition. Cognitive rehabilitation may also be considered for those with prolonged symptoms and functional impairment. However, confounding factors, such as anxiety and depression,

should always be on the differential, as they too can lead to difficulties with concentration and memory.

Sleep Disturbance
Sleep disturbance is a very common symptom following concussion. A retrospective chart review of 417 concussion patients from Penn State found that 34% of concussion patients reported disturbance in sleep and that sleep disturbance was associated with a 3-to-4 fold increase in recovery time.

To assess sleep, a good history is essential, asking questions about changes in sleep pattern, sleep hygiene and timing, symptoms of insomnia, fatigue during the day, etc. Having the patient keep a diary to log their sleep may also help with re-assessment.

For management, sleep problems are initially treated with education on appropriate sleep hygiene (i.e. removing electronics, calendars, and textbooks, or anything else that can trigger anxiety in the bedroom). Another important aspect is avoiding naps and maintaining the same bedtime and wake up time each day. Avoidance of substances that increase alertness such as caffeine and nicotine should also be avoided. Then, if conservative measures do not improve sleep, medication or supplements can be considered. For example, melatonin has been found to be beneficial in improving sleep and recovery time for many concussed patients. Amongst the patients in the Penn State study, 67% reported reduced sleep disturbance with melatonin.

CASE REVISITED
Coming back to our case, what treatment options might Bobby benefit from? While there is no specific intervention shown to improve recovery, the evidence says the most effective plan is to treat his specific symptoms. Bobby continues to suffer from daily migraines, depression, and difficulty sleeping. There are several pharmacotherapy options that could benefit Bobby. It would be reasonable to have a discussion with him and his family to consider starting an SSRI for his depression, and/or Vitamin B12 and magnesium for his migraines. Additionally, an offered referral for CBT with a psychologist, or recommendation to see a counsellor, to help cope with his difficult circumstances, may be warranted. In terms of help with sleep, melatonin would be also be a safe and effective option, to help him regulate his sleep a bit better. He could also be provided with various resources.

For useful and informative resources, we recommend:

- The Education and Support webpage at the Canadian Concussion Centre at Toronto Western (https://www.uhn.ca/KNC/Research/Projects/Canadian_Concussion_Centre/Pages/patient.aspx)
- The Regional Acquired Brain Injury Program webpage at Saint Joseph's Health Care in London Ontario (https://www.sjhc.london.on.ca/regional-acquired-brain-injury-program/patients/vision)

Developed by Adam Neufeld, Brendan Lee, and Dr. Kowalczyk for PedsCases.com.
October 31, 2020.

- Both of these websites include helpful tips to help manage symptoms, coping strategies for patients and family members, and information about PCS in general

After consulting with his doctor about these treatment options, Bobby is interested in pharmacotherapy and meeting with a counselor. He does not like the idea of taking medications but is desperate for any type of relief. His doctor continues to say that time will be the most important and effective treatment. Although he is tired of hearing this, he is comforted with some reassurance that he will get better in time.

CASE REVISITED:
Bobby comes back after 6 weeks of treatment with an SSRI, B12 and Mg+, and amitriptyline. His mood has been a bit better but he has not had any improvements with his migraines. He would like to continue with the SSRI and discontinue the amitriptyline or look at other options. He also remarks that he has been doing a lot of research on the internet and is scheduled to see a chiropractor trained in chiropractic neurology who mostly works with concussion patients. He would like to know your opinion.

The treatment and pathophysiology of persistent concussion symptoms is very controversial and often difficult for physicians to treat. Additionally, there is a wealth of information accessible to patients on the internet that claims to be effective or even cure persistent concussion symptoms. Patients can often spend large sums of money on various forms of treatment such as programs offered by chiropractors, optometrists, and various forms of technology. Many treatment programs are not founded on evidence or research and are solely anecdotal or theoretical.

While Bobby is very hopeful that chiropractic therapy could be helpful, it is important to warn him that these treatments are not studied and could potentially be harmful. Specifically, assure that if he does decide to try chiropractic treatment that his neck should not be modified, as that could be very dangerous, especially for a patient recovering from a head and neck injury. After discussing this with his doctor, Bobby decides he will still see the chiropractor.

CASE REVISITED
After nearly 8 months of symptoms, Bobby is starting to feel better. He has returned to being physically active and his migraines are not as frequent. He is still more sensitive to light on his computer and phone and he has some ongoing tinnitus in his left ear. Nonetheless, he is doing much better and feels like he is finally getting closer to being able to return to school, hopeful that his remaining symptoms will continue to subside with time.

That's a lot of information in one sitting, so let's wrap this PedsCases podcast up with the major takeaway points!

6. Summary of key points:

1. Prolonged post-concussive symptoms or “PPCS” is typically caused by mild traumatic brain injury and is a growing cause of morbidity and poor quality of life, with symptoms lasting for weeks to months, in some cases, longer. These symptoms are thought to stem from both structural damage to the brain and psychogenic factors.
2. Although there is no agreed upon standard of care or treatment intervention for PPCS, its symptoms are generally broken down into 3 main categories: cognitive (attention and memory), somatic (headache, fatigue, insomnia, tinnitus, dizziness), and affective (depression, anxiety, irritability). Often patients have overlapping symptoms from each category which are not mutually exclusive.
3. In terms of risk factors, the literature points to adolescent age, gender (females reportedly more), and most importantly a history of prior concussion or head injury. In the latter case, repeated brain injuries are thought to lower the threshold at which PPCS can develop, which makes seemingly mild injuries or symptoms appear harmless at first. The takeaway from this? When in doubt, sit it out!
4. To date, most of today’s treatments have little effect on PPCS when challenged scientifically. This is because they primarily target symptoms and not the pathophysiology, which is still poorly understood. Pharmacotherapies have been found to help with treating comorbid symptoms (e.g. depression, sleep issues, migraines), and various other cognitive and physical therapies might all be beneficial as well (e.g. CBT, exercise, vestibular rehab, physiotherapy, massage, and acupuncture); however, there is little evidence supporting their benefit to actual PPCS symptoms, at this time. These may be experimental and have individual differences in response.

Thanks for listening. We hope this podcast has been beneficial for your learning and will help your practice!

Developed by Adam Neufeld, Brendan Lee, and Dr. Kowalczyk for PedsCases.com.
October 31, 2020.

References

Davis, G. A., Ellenbogen, R. G., Bailes, J., Cantu, R. C., Johnston, K. M., Manley, G. T., … McCrory, P. (2018). The Berlin international consensus meeting on concussion in sport. *Neurosurgery*. https://doi.org/10.1093/neuros/nyx344

Eisenberg, M. A., Andrea, J., Meehan, W., & Mannix, R. (2013). Time Interval Between Concussions and Symptom Duration. *PEDIATRICS*. https://doi.org/10.1542/peds.2013-0432

Makdissi, M., Cantu, R. C., Johnston, K. M., McCrory, P., & Meeuwisse, W. H. (2013). The difficult concussion patient: What is the best approach to investigation and management of persistent (>10 days) postconcussive symptoms? *British Journal of Sports Medicine*. https://doi.org/10.1136/bjsports-2013-092255

McCrory, P., Meeuwisse, W., Dvorak, J., Aubry, M., Bailes, J., Broglio, S., … Vos, P. E. (2017). Consensus statement on concussion in sport—the 5th international conference on concussion in sport. *British Journal of Sports Medicine*.

Developed by Adam Neufeld, Brendan Lee, and Dr. Kowalczyk for PedsCases.com.
October 31, 2020.