



Volume 9, Bonus Issue

Concussion

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Learning Objectives

- Describe how brain injuries in children differ from those afflicting adults.
- Delineate how a concussion is diagnosed and how any symptoms should be treated.
- Define the second impact syndrome and the cumulative risk from multiple concussive episodes.

Technical Requirements

System requirements for listening to MP3 files and viewing transcripts:

Adobe Acrobat Reader 7.0 installed on your system and 16-bit sound card with speakers

Macintosh minimum requirements:

PowerPC G4, G5 or Intel processor; Mac OS X 10.4 (Tiger) or later; 128MB of RAM; 250MB of available HDD space; QuickTime v4.x or later; CD-ROM drive; speakers and sound capacity; browser which supports 128-bit encryption.

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Transcript of the Panel Discussion
as recorded on the Audio CD

Numbers indicate CD Track

1 *Introduction*

2 **Dr. Metzl:** My name is Dr. Jordan Metzl. I'm a sports medicine physician at Hospital for Special Surgery in New York City, and I have nothing to disclose.

Dr. Kinderknecht: I'm Jim Kinderknecht and I'm the director for the Primary Care Sports Medicine Fellowship at the Hospital for Special Surgery, and I have nothing to disclose.

Dr. Kosofsky: I'm Barry Kosofsky. I am the chief of Child Neurology at Weill Cornell Medical College, where I am also the Goldsmith Professor of Pediatrics, Neuroscience, Neurology and Radiology, and I have nothing to disclose.

3 **Dr. Metzl:** Concussion, an injury which has just become incredibly pervasive.

Jim, my first question to you is, when somebody says, "I've had a concussion," what does that mean? Because people are so worried about it. Many people don't know exactly what it is. How would you define a concussion?

Dr. Kinderknecht: The biggest misperception is that you have to be knocked out to have a concussion. It's nothing we can see. It's not a computed axial tomography (CAT) scan, magnetic resonance imaging (MRI) scan type of diagnosis. It's a clinical diagnosis.

The simplest definition is this altered state of mental awareness. It's a traumatic event that creates an altered sense of awareness, and symptomology associated with that that can be quite variable.

Dr. Metzl: Barry, are you comfortable with that definition?

Dr. Kosofsky: I think that's a good first approximation, and I agree with Jim. It's very confusing because the pendulum swung from you only had a concussion if you were knocked out, to now every time somebody has any blow to the head they've had a concussion. We're seeing so many more parents bringing kids to the pediatricians and to the child neurologist and to the emergency room with trivial head injuries.

One of the challenges for the parents is, "When do I

bring my child, and what is significant." That's the key point that Jim's making, that there's some change in alertness, some change in awareness; that's an important point to key on because that's what we worry about as neurologists.

4 **Dr. Metzl:** The question then is, are we doing a better job of recognizing this injury, or are we actually seeing this injury more often? There's much more awareness about this buzzword of *concussion*, and the pendulum swing is a great analogy. In the early days of football in the 1970s, 1980s, high school football, college football, you got a dinger. You got your bell rung. And it wasn't taken too seriously. And now, I think we've swung so far that every single hit in the head, people are worried about a concussion. Barry, what do you think? Are we seeing more concussive episodes, or are we just doing a better job of recognizing those things which we didn't take as seriously before?

Dr. Kosofsky: We are recognizing it more because I think a lot of children who wouldn't have come to our attention are now brought to our attention. So, it's increased awareness and in particular increased concern, but I think there is increased risk because more children are playing sports, especially at younger ages.

5 **Dr. Metzl:** Jim, when you think about kids playing sport and pediatric and adolescent concussion versus an National Football League (NFL) football player who has a concussion, should pediatricians, when dealing with this injury, approach the 10-year-old soccer player, the 14-year-old football player differently than when they think about a college athlete or a professional athlete when it comes to concussion?

Dr. Kinderknecht: Yes. The pediatric brain is different than the adolescent brain, is different than the adult brain. My encouragement would be that eventually we get to a point where nothing's mild in the world of a head injury and a traumatic brain injury. And so, unfortunately, for the longest time, I think we were doing the whole diagnosis a disservice when we were trying to diagnose as mild, moderate, or severe because I think when you diagnose, most of these do categorize into the mild category, but I think it's a misnomer that they were truly mild.

Now, getting to your question and that is about the adolescent brain versus the adult brain, there clearly are differences. Some of those have been defined; some of those have not been defined. The whole concept of *second*

impact syndrome, which is a devastating potential outcome of a second injury on top of a concussion, is what appears just doesn't happen probably in a brain that's over 21 to 22 years of age, or it sure doesn't look to be. If it happens, it's almost never, as opposed to that brain that that can happen to and with the outcome being death in that situation.

So, it is much more appropriate to be amazingly more conservative in the adolescent and child brain.

6 Dr. Metz: Barry, this question of pediatric and adolescent concussion versus adult concussion can be confusing to people because when they watch an National Basketball Association (NBA) player or a soccer player and they're cleared relatively quickly after having a concussion, and they try and apply that logic to a young athlete. The worry is that the force needed to induce a concussion might be higher in a kid. Certainly the recovery period seems to be longer in kids than it does in adults for the same type of injury. So as a child neurologist, what kind of things do you think about talking to pediatricians and parents about when it comes to kid concussions versus adult concussions?

Dr. Kosofsky: One of the most important components of understanding how kids are different is mechanical. The child's head is a much bigger part of their body, and their neck muscles are not as well developed. So, they are kind of like bobbleheads. That puts the 6-, 8-, 10-year-old child at greater risk for torsional injury. That is really the pathophysiology of concussion:-shear injury.

The brain is kind of like a stalk of broccoli: you've got the flower on the top and the stalk on the bottom. And what happens with acceleration or deceleration or rotational injury is that there's a stretching of the fibers where the stalk meets the flower, and at that junction there's what we call *shear injury*. When axons that connect the fibers that are running in the stalk get stretched, then the fibers aren't working.

The point about the head being bigger and the neck being weaker; with the same impact, these children can have greater torsional rotation and greater strain and greater shear on those fibers. The anecdotes are that it's the only injury to the brain where children heal slower than adults. That gets us as scientists thinking about two things in combination: is it slower because the same impact causes more damage, or even with the same damage, is it slower to recover because the brain is in a more immature state? I think the answer to both questions is yes.

7 Dr. Metz: If somebody breaks their wrist, you can put their x-ray up and say, "Listen, this is a distal radius fracture. It's going to be 30% healed in 3 weeks. It's going to be 60% to 70% healed in a month, and by about 6 weeks it should be pretty good, and you should be able to get back to playing." The tough thing about this injury, I think in kids particularly, is that it's very difficult to give an exact timetable. In the youth athlete particularly, with this long period of healing, it's very difficult to say, "You will be better now," that this gradation of healing is very different and seems to be independent somewhat of the level of severity, which makes this very difficult. No two concussions are the same. And I think on the sports medicine side, that makes it tough for us. Jim, what do you think?

Dr. Kinderknecht: Yes. The strange part is the mildest concussion can have the most persisting symptoms, and the person that gets knocked out is fine a day or two later and has no symptoms. There does not seem to be a correlate with the degree of what happens at the moment of injury as far as predicting the future.

In terms of predicting of how fast are they going to get better, we do know that with the younger brain, those symptoms seem to resolve slower than in adults. The question I've always wondered, is a kid just way more honest than adults? Maybe the adults are having symptoms too and they just don't tell us. That's one of the big things about concussions and the management of those: the problem is it's very much at the discretion of the patient and their reporting of symptoms that helps guide us in terms of our diagnosis and in terms of our treatment and return to activity and play.

8 Dr. Metz: Barry, is there any reason why the pediatric concussion would heal slower? Is the physiology the same and it's just the mechanics of the injury being a bit different based on the rotational force of the brain?

Dr. Kosofsky: I don't know the answer to that, and lots of people are trying to figure it out. There are a lot of animal models, and there's a lot of effort in humans to try to figure it out.

In the nervous system, one thing we know is it's not just what happens, torsional injury, that leads to axonal shear, but where it happens. What we're finding is that on the research side, when you do see structural brain injury associated with concussion, if it's in particular parts of the brain, it's more likely to contribute to more long-lasting problems with attention and learning.

Now, why would that be more evident in children? Because they're still developing those pathways until age 25. Some of these attentional networks that are in the frontal lobe and pathways that connect the front of the brain with the temporal part of the brain, the uncinate fasciculus and the front of the brain with the back of the brain, the superior longitudinal fasciculus, when those are injured, those are the individuals that are more likely to have long-term problems with attention and focus, and that seems to be what gets people into trouble.

I agree with both of you that it's hard to predict who's going to have the long-term trouble and who won't. Most people will get better. So, you don't really know how aggressive to be up front. It's the kids that don't get better that then come to my clinic where I have to make a decision: "Do you need medication to prevent the headache?"

The key about concussion-induced headache is it's physical and mental exertion-induced headache. For me, that's really the signature, that when an individual tries to concentrate in school or push themselves athletically and they bring on the headache, that is the sign that it's a postconcussive headache syndrome.

That gets to your point, "What's the biology of that?" We think it's increased blood flow to the brain that's triggering the symptoms. So, the suggestion is that the control of blood flow following a traumatic brain injury is going to be altered. In those individuals that can't regulate blood flow after the injury, they're the ones who are going to experience more headache when they challenge themselves afterwards.

I'm telling you two things. One, there's a structural piece of it in terms of the connection between different brain structures, but there's also a functional piece, which is blood flow that seems to be altered.

Another example of that is if you look at individuals who have postconcussive syndromes in the weeks to months out, their brains have lower rates of metabolism. It's very surprising how global and long-lived these changes can be. We see it on the outside, but you can also see it using positron-emission tomography (PET) scanning.

Dr. Metz: We've done a good job of defining the scientific questions and some of the epidemiology around this.

9 Now, I want to try and get into some clinical issues.

Jim, you are in Missouri and you have a 13-year-old soccer-playing female. She comes in to see you. She got hit in the head a few days ago, and she comes in complaining of a little bit of a headache. She comes in with

her parents and her parents are very worried about it, but they're not sure if in fact she's had a concussion or not, and she wants to get back to playing soccer.

What are you going to do? What are some of the things you're going to think about?

Dr. Kinderknecht: The first thing I'm going to try to do is get her to define what happened and what she remembers. You're trying to make a clinical diagnosis.

If she has a blow to the head, if there's an altered state of awareness, if there's a headache in someone that's never had headaches before, the other things I'm going to explore at that point are her level of concentration, her ability to be attentive in class, read, and comprehend. One question I ask a lot is the computer question: does eye stimuli bring out the headache? So, I'll ask about screensavers, videogames, and that type of thing. I don't know if I've ever seen an athlete that truly had a concussion that could play a videogame.

I'll look for some other clinical indicators. The question at that point is, do I image that person or not? I do a physical exam, looking for any focal neurological findings. I think anything that's focal warrants imaging. If there's no focal findings and depending on how symptomatic that person is, I may follow them for a few days before I decide on any imaging. If they're not clearing, or if they have any increase in symptoms, then I'm going to consider imaging.

When I send the patient for imaging, I preface that by always telling the parents that this study is not going to make the diagnosis. It's more to make sure there's nothing more than a concussion. In that setting, really you're looking for structural changes. Make sure they understand that if this is negative, it does not mean they don't have a concussion.

Dr. Metz: And that's consistent with what we've been talking about in terms of this person comes in, she's got some symptoms, and in olden days, we may have—based on our different criteria on loss of consciousness or not, or different grade—we may not have called her a concussion, maybe somebody just with postconcussive symptomatology of X. And now, we're kind of in this world where she's got these symptoms for several days. The terminology is a little more lax in terms of saying in fact, that does sound like a concussive episode, just based on the fact that she's still symptomatic and sitting in your office.

Dr. Kosofsky: The questions that I ask are: was there loss of consciousness or any peritraumatic amnesia where

an individual doesn't remember before, during, or after the event? The two things I look at on the exam are whether there's any blurring of the disc margin, which we would hope there isn't any swelling. That's a different kind of headache. That's a pressure headache where individuals have more headache lying down and they're better standing up. Those are the ones that we worry about as neurologists, where it'll wake children out of their sleep.

The other physical sign is looking at horizontal eye movements, and there's a coarseness in visual pursuit. Those are the children that I'll more likely want to image. Those are the ones that are more likely to have some kind of structural abnormality.

Jim is absolutely right that these are insensitive tests. The shear injury I mentioned, you can see it with research-based diffusion tensor imaging on MRI, but your standard MRI is more sensitive than your standard computed tomography (CT). The broccoli has really got to have pulled from the stalk to see that on a CT scan, where you sometimes get little spots of blood where the broccoli meets the stalk at the gray/white border.

Blood is easier to pick up on MRI, but some of these more subtle changes are not evident. I seldom image children except for research basis because there is nothing I am going to see on the MRI that is going to change my management. The point that Jim makes, if it is normal, I don't want them returning back to sports or even to academics if they are still symptomatic.

- 10 **Dr. Metz:** So now, we have this girl and she's got this headache for a few days. I think the two questions that we commonly get in this situation are, number one, the parents are, "When should I be sending her to school?" And the kid is, "When can I go back on the sports field?"

The way I approach those, getting back into the classroom precedes getting onto the sports field. And I think medically, the risk of getting back into the classroom is less, or hopefully should be less than getting back onto the sports field. So, I think the first part of that question then is this issue of cognitive rest, resting the brain. What I generally do is, I grade this out and—much like I will gradually get somebody back into sport—before I do that, I'll gradually get them back into school; so I will initially try to restrict some of those visual stimuli and then as they feel better, get them back into some period of time. Maybe they go to school for a couple of hours, and then a few hours, etc. And that process can be different for everybody.

But, Jim, with an athlete and the issue of cognitive return to activity, how do you do that?

Dr. Kinderknecht: That brings up an important thing that I think is really confusing to most clinicians and that is cognitive rest. Does rest help the brain recover, or does that help control symptoms? I'm less convinced that cognitive rest is needed to get over the injury. I'm very convinced that you need cognitive rest to control the symptoms.

So, I think it does come down to symptom and symptom control. The less symptomatic they are, the more liberal I am going to be with letting them go back to school. There are some data that relative exertion a few weeks in may help recovery, or again, may help with symptoms.

There really are two issues and two questions, and that is the natural history of the injury, and healing and symptom control.

- 11 **Dr. Metz:** Does resting the brain accelerate healing, or does it just control symptoms, Barry?

Dr. Kosofsky: I'm with Jim, that I think it is really controlling symptoms. Jordan, you're on target when you say you can't let somebody back on the ball field and then they don't go to school. Similarly, I don't let kids use their screens and keyboards if they are not walking around the house and socializing. I'd rather have them lay low and titrate their activities based on their symptoms across both the athletics as well as the academics, and they should go hand in hand.

Back to Jim's point, there are some kids that get into more trouble with sounds, and some with visual, and some with balance, and some with trying to go up and down stairs, and it probably has to do with which part of the brain got affected. So, you have got to listen to the patients carefully and say, "Do you have trouble when you're in the car? Do you have trouble when you're in the lunchroom?" The lunchroom has all the sensory symptoms. Or is it the visual problem, looking at the board and then copying to your notebook, because that tells me when I bring that child back in, these are kinds of challenges that child is going to have.

When I do bring them back to school, I usually start at the end of the day: Go back for eighth period, then seventh and eighth period, so they are getting a little bit of school, a little bit of socialization. Most of the hard academic subjects are earlier in the day. You don't want children to stay home; you want to get them to start getting their activities back in order. But then the trick is, do they need resource room time and, if so, for what subjects and for what kind of challenges? And that is where you have got to tease out which part of the nervous system is most sensitive to the symptoms.

Dr. Metzl: Now, just a quick follow-up question for you and that is this issue of returning them to activity while their brain is recovering on a scholastic point of view. Do you wait until they are fully able to go through the full day of school with no symptoms until you even discuss getting back on the sports field?

Dr. Kosofsky: I try to do it in parallel and it is complicated. And the way I play it is you have to be headache free for 2 weeks before you can initiate any kind of cardio, and then you escalate to doing drills, scrimmage, games over another 2 weeks. So, you are 4 weeks out.

Each of us have our own ways of handling this, but what that buys me is 2 weeks where they are going to try to be in school and challenge themselves. If they get headache, the clock resets to zero. So, they don't get a chance to be on the ball field. I want them to be 2 weeks out before they start the cardio. Then they are challenging themselves by escalating the mental exertion before the physical exertion.

Now, sometimes they don't go hand in hand. I've had some individuals that the physical exertion induces the headache and others in whom it's the mental exertion. It's not to say that headache is the only symptom that is worrisome. There are children that have brain fog, or the lack of clarity of thinking, and there are others that have more this imbalance, more of a vertigo-type of syndrome.

So, there are different symptoms and again, it may be genetics. It may be the individual. It may be the hit. We don't really know, but I agree with Jim that you have to listen to the symptoms. I tell the patient, "When you have headache, it's your brain telling you, 'Stop what you're doing.' It's not that you're causing more injury. It's just not ready to do it, and you shouldn't do that activity for another 2 or 3 days."

I can't predict, as Jim said, who is going to fly, and in a week or two be better, and who is going to be a month or two still sidelined. It's really empiric.

Dr. Metzl: What I've been using is the American Academy of Pediatrics (AAP) return to activity guidelines in their position statement on pediatric and adolescent concussion. That's available on www.AAP.org, and that's a very helpful table that I print out and give to my patients. It's the same kind of concept, that basically you need to be neurologically clear, headache free, and you go to zone one to zone two to zone three and there's different steps along the way. You need to pass each step before you go to the next step. And if you basically get any symptoms, you have to go back to the step before.

You're doing is the same thing, step-wise return to activity, which in some ways we spent a lot of energy in the first 20 years of thinking about concussion, thinking about the diagnostic side. I think we're doing a much better job now focusing our efforts on the return to activity side, which is, I think, much more important. Jim, what do you think about that?

12 Dr. Kinderknecht: If you're not over your concussion and you exert yourself—and I'll make a point: when we say *exertion*, the key is non-contact exertional activities and graded exertion, because that's not a setting in which they can create trauma. Now, you can't 100% control that, but for the most part, you can.

And it pertains to the NFL. It pertains to all levels. If the ace in the hole we have is exertion and if exertion brings out symptoms, it's our most sensitive indicator that the concussion is not resolved. Here's the problem. It requires that individual to tell us they have symptoms.

Now, I think so much of this is why primary care physicians are in the best position for this because they know these patients and these children the best. They have a rapport. I just think that a lot of times these individuals, the pediatric patients, are much more willing to be up front with the physicians they feel comfortable with. It's so vitally important that every primary care physician get comfortable treating head injuries because it makes sense in terms of front-line diagnosis and reporting of symptoms.

My approach is probably a little more aggressive than Barry's, but the question is, how long do you leave them out? And so, I've kind of gone for more of the approach: if you have 2 days' worth of symptoms, then you need to be clear for 2 days. If you have 2 weeks of symptoms, you need to be clear for 2 weeks.

And so, I've used that approach, but it's always coming down to the ace in the hole, in my opinion, and that is this exertional test that most state regulations are now adopting, very appropriately so. And the gray zone is how many days of nonsymptoms and then how many days of exertion and so on and so forth.

Dr. Metzl: To summarize this piece of the discussion, it seems like we're all three in agreement that somebody has a head injury, a concussive episode, and that the way we will gradually return them to activity is to initially start them in their scholastic endeavors, wait until those scholastic endeavors are symptom free, then start them in some kind of exertion without contact, wait until that is fully symptom free. And when they are fully symptom free at school, fully symptom free with exertion, then

introduce contact level sport. Jim, from a sports perspective, do you agree with that?

Dr. Kinderknecht: Yes. That's the sequence of events we go through. There's a lot of other tools that we're trying to utilize in terms of neuropsychiatric testing, the computer-based things that may aid us in this progression. And in terms of somewhat getting a sense of the severity, we use eye tracking, physical exam findings. But in the end, I think it does come down to monitoring symptoms.

- 13 **Dr. Metz:** There is increasing enthusiasm on the use of neuropsychiatric testing, both as a baseline testing before the season and as a return to activity after this injury has happened. In the 1980s, there was a whole push towards using paper-based neuropsychiatric testing. And then over the last period of 15 to 20 years, there's been the genesis of computer-based neuropsychiatric testing, which is largely office based and now school based. And initially, that was done on the professional levels, then in college levels, and now in high school levels.

So Barry, we've got these more expensive tests that people are excited about. There are whole companies that are actually making quite a lot of money off of these office-based neuropsychological tests. Does that help us at all, and does every pediatrician need to get this for the office?

Dr. Kosofsky: I see no value in the neuropsychological tests. I find them to be inconsistent in terms of the test/retest and unreliable in helping me make decisions about where somebody was, and where they are now, and where they're going to be.

I can't say in every case that all these tests won't work and that it won't work for everybody. The problem, as we know in professional athletes, is that they will "sand-bag" on the tests so that they will have a low baseline. If they do then have a concussion, they won't show interval worsening, so they'll be able to keep playing. I don't think the high school athletes are thinking that way and certainly not the junior high school athletes, but they're still not taking the test particularly seriously. Then when they do focus on the test after they do have a concussion, often they will do better after the concussion than they did at baseline.

The idea of having a baseline testing that is sensitive is great. Our approach has been more towards a biomarker, something that you can see on the outside that is reflective of brain function on the inside. And everybody is looking for that Holy Grail. Is it balance? Is it eye tracking?

We want to objectify this as we know pencil and paper are not great. People tell you the answers they think you want to hear. And we know that screen-based testing is a little more objective, but still not particularly sensitive, at least not in everybody. The idea of longitudinal testing was supposed to help us see interval change, but it really, in my hands, hasn't borne out.

Dr. Metz: Jim, are you going to buy neuropsychological testing as part of your pediatric office of the next century?

Dr. Kinderknecht: My thoughts are not any different than Barry's. But to be honest with you, the train's left the station. They're going to be utilized partly because there's organizations that are utilizing them. Unfortunately, the use of those at a higher level, if you will—the NFL, National Hockey League (NHL), Major League Baseball, and the like—unfortunately I think it's somewhat validated the tool when the tool hasn't truly been validated. I think if you use it in the sense that it's a piece of the puzzle trying to help you, you understand it has significant limitations—just like any test, you fit that into the other pieces of the puzzle, I think you can utilize it.

Where I become concerned is when it's the test that it is driving the decision making. I think that is very inappropriate and somewhat scary. To me, either the test stands alone without symptoms, or it doesn't really add much to what I do. So, I think it's always important to understand, why did they fail the test? Without baseline, they are worthless.

- 14 **Dr. Metz:** The office-based neuropsychological and the computer-based neuropsychological test has certainly been something which has been received very enthusiastically and is widespread in its use in many different levels of sport. That in the pediatric and adolescent patient, it's not something you want to hang your hat on it.

First, you get their baseline and then what we do in the schools that we work with is, when they are fully asymptomatic—no self-reported symptoms, no headache, no photophobia, not increased anxiety, no sleep problem, no symptoms at all that we commonly associate with postconcussive-type symptoms—then they can take their second test and see how they do, but it really is not until a point where I would be comfortable returning them to the sport already. Because I think if you start using that then as your decision-making inflex point in terms are you going to put them back on the field or not, you're really opening yourself to problems. Barry, do you have a thought on that?

Dr. Kosofsky: We as clinicians like numbers. We like a formal test, but this is a clinical diagnosis. If you want to say, are they at baseline, school performance is probably the most sensitive way to pick that up. Like Jim was saying, the relationship with the general pediatrician in terms of affect, are they labile, are they flat, and the parents will pick up on that. But in terms of attention and learning, school is a very sensitive setting

It is real important to try to get that information because we don't really want a noun: "You're concussed, you're not concussed." We want a verb: "What can't you do as well as you used to do?" Because that is the starting point for the appropriate intervention, whether it is curricular support or remedial assistance. And then we know, "Here's our target. We are going to try to get you to do better at reading," or "We are going to get you to do better at paying attention or organizing your day."

So, I think waiting until the symptoms resolve and then trying to say, "What's left in an operational way?" is the smartest way to approach this.

15 **Dr. Metz:** Does every kid with a concussion need to see a child neurologist, Jim?

Dr. Kinderknecht: First of all, they're too frequent. It wouldn't be possible. This is too common of an injury for every concussed athlete to see a neurologist.

The answer with most of these is they get better. Manage them appropriately, save the ones for the pediatric neurologist that don't act like they should. If they veer away from that and there's some quirkiness about it, or they're not getting better, that's where the referrals are appropriate.

The real challenge that I have is when do I try to control symptoms and when don't I, because the majority of the symptoms are going to go away. I'm a bit of a minimalist when it comes to treating symptoms.

There are no medications that we know of that alter the course of the disease. All medications are really, at best, going to control symptoms while the problem goes away. We've got to have primary care physicians that are capable of managing this in its entry-level phase and then understanding when it needs to be referred.

Dr. Metz: Does every child concussion need to see a child neurologist, Barry?

Dr. Kosofsky: I hope not. We opened a concussion clinic and when we weren't that busy, we were taking everybody within 2 and 3 days We just got so busy that

I have to wait 2 weeks, and I like that, because most of these are going to go away within 2 weeks. And if it doesn't go away, then I need to think about why isn't it going away.

The first line is the pediatrician, the second line is the emergency room, and a lot of these families are just coming to me to hear what's the return to play? The Academy's recommendation could be disseminated by the pediatrician or the emergency room if the parents take them there—they don't have to see me. They know what to do during those next 2 weeks, and for the most part, the symptoms are going to go away.

Then if they come to see me in 2 weeks, I don't want to start them on medication, even if they are still having physical or mental exertion-induced headaches. So, I try to buy some time by using brain vitamins. There are some data from the military from traumatic brain injury: that you could use things like magnesium or riboflavin (vitamin B2), coenzyme Q10, fish oil (omega-3), vitamin D in any combination. And I don't know for whom they work the best. They are over the counter, they're not that expensive. And then it buys me 2 more weeks.

I give out a headache diary to everybody at the 2 week when they get into the clinic. They are going to tell me what is triggering the headache and how significant is it. Just one piece of paper: how many days did you have headaches, how bad were they, and what brought them on.

Then, I'm at a point where do I need to initiate an everyday medication. And most of my meds to prevent headaches take another 2 weeks to work. So now, I'm 6 weeks out, and it's only those kids that are going to have headaches for 6 weeks that are going to need a medicine. So that's why I want to hold it off and only give it to the kids who really are not getting better on their own.

Dr. Metz: It sounds like we're all saying the same thing, that if you're a pediatrician for us on the sports medicine side as well, we're certainly comfortable taking care of the vast majority of these episodes. But, it's those which are persistent, outside of the norm, that seem to require further intervention.

Dr. Kinderknecht: Most of these steadily get better. The typical course is they come in with symptoms and every 2, even 1 day, they get better, and that's what you're really looking for. The ones that seem to plateau out in terms of their improvement, and the big red flag is the individual who has increasing symptoms at any point. And the more concerning one is when it has no correlate to what level of activity or exposure to noise or what have you.

16 Dr. Kinderknecht: Jordan, what are your tricks to keep that athlete off the field when they shouldn't be there?

Dr. Metz: We want to give kids the best information, but they really want to play. And so, how does the pediatrician or a sports medicine doctor or a neurologist impart the feeling that what you're telling them is actually the best medical advice for them? And I think the answer is that kid athletes are great people. If they know that you are on their team, that goes a really long way, I have found.

I look them right in the face, and I say. "Listen, I really value your athletics for you. I realize how important it is for you, and I want to make sure that you're not playing for next week, but you're playing for next month or next year, and that my decision on how to take care of this concussion is difficult because it's not something that shows up on any specific test. We're going to have to work together as a team, but that both of our goals are the same, to keep you on this sports field not only now, but for next month and next year."

And I think if we can give our patients the feeling for whatever it is, sports medicine related, that we are actually on their team and looking out for their best interest, that sense of the doctor working against the patient is really replaced by a sense that we're all on the same team together. And I think it makes a very big difference.

17 So, Stephen is a 16-year-old guy. This guy loves playing football, and he has just come to see you for what looks to be his third concussion in the last 4 years.

Barry, this guy comes in to see you and he really, really wants to play football. He's slowly recovering. His concussion was about a week ago, but his parents are worried because Stephen has had three concussions. So, the question to you is, how many concussions are too many, and how often do you have that discussion in your office?

Dr. Kosofsky: We have it every week, and I can tell the parents who want to talk to me before we go in the room: "Could we have a few words?" The words are going to be, "I don't want my son playing or my daughter playing. Could you please talk them out of it?"

I couldn't provide evidence about what the cumulative risk is. Part of why we have this slow return to play is we want to make sure that an athlete's timing and judgment and balance are normal, because otherwise they do put themselves at risk for another concussion.

This is slightly different than what Jim was talking about, second concussion syndrome, which is another entity. What we talk about is, are you at risk for making

bad judgments on the field because you are not back to 100%. And that's where that 2 extra weeks of escalating after the first 2 weeks—4 weeks from your last headache—buys you a little bit of protection.

I have the three-strike rule. I want to work with the kids, but the argument I usually make is this. The epidemiology of this problem has become children in junior high school and high school. For every one player in the NFL, there's 100 players in the National Collegiate Athletic Association (NCAA) and there's 10,000 players that are at the high school level. Are you destined to greatness? It's most likely you are not going to be a professional athlete.

Even though this is the most important thing in your world right now, and although your identity is tied up with being on the football team, it may not be in 3 years or 5 years. The value added by that experience may be offset by not being fully capable of going to college due to recurrent concussions. It's a judgment call, and it really has to be made by the child and the family.

The three strikes is arbitrary, but some kids are more prone. And I don't know whether it's because they are more risk-taking on the field, or whether their judgment or balance is off, or their body structure.

Dr. Metz: This becomes the crux of what many pediatricians are dealing with around the country, that this injury has happened. It happened last year. It happened the year before. They come in in their pre-participation exam, and this is a kid who had had a couple of concussions.

We're very comfortable in sports medicine saying, "You've had shoulder instability. Your shoulder has come out X amount of times, and so we know your shoulder is going to keep coming out," or "You're had shin splints and we know that, based on how you run, the mechanics of your feet or your bone density, you're much more likely to have shin splints year after year." And yet, there's something about this concussive predisposition, somebody who's more likely because of either how they play or how their brain is built—or some combination of how they play and how their brain is built—that they're more likely to get this injury and get it over and over and over again. How many are too many?

And I have a three-strike rule also. I try and figure out does the punishment fit the crime? Are these kind of light injuries that seem to result in persistent neurological symptoms, or is this somebody's who really had a very big rotatory injury, hit on the side of the head several times in several injury patterns? Which makes a little more sense to me?

18 Jim, I'm going to ask you the same question I asked Barry. When do you start thinking about how many is too many for a kid playing a high-contact sport?

Dr. Kinderknecht: When I get someone in my office with more than one concussion, I really try to get the sense whether it's really they never got over their first one, and concussion two and concussion three are really concussion one never resolved. That factors into my decision making to some degree.

The other thing I really try to gauge is to how symptomatic they are for how long. I'm a lot more worried about an individual who has a more prolonged course than somebody who clears in a handful of days.

Those are two factors that I add into things. If somebody has a concussion in ninth grade and has a concussion in 12th grade, that's not as concerning. Whether one concussion makes you more prone to the second one? Seeing athletes at the collegiate and professional level, it seems like they either have had zero or they've had three over the course of their career.

So, whether the first one set them up for the second one 2 years later, I don't know. Is it their anatomy that's setting them up? Is it their technique in the way they play their sport that's setting them up? But, there does seem to be a tremendous grouping that very anecdotally, like I say, I'll see somebody who has had three over maybe 8 years in their career, or the answer is "I've never had one."

19 **Dr. Metz:** This is a good time to mention that not all sports are created equal. If you have somebody who has a concussive predisposition playing football, that does not mean they shouldn't do any activity. It means that they should do a medium- or less-contact sport. So, baseball may not be a problem, or tennis wouldn't be a problem. It doesn't mean they shouldn't do any activity.

Dr. Kinderknecht: That's the one thing that confuses people because historically, people have tried to divide sports into contact or non-contact. Probably the way to look at them really is collision versus contact versus non-contact. And so, there's certain sports—football, hockey—that are clearly collision sports, which is different than basketball—that's a contact sport, which is different than swimming, which is a non-contact sport.

Dr. Metz: That's an interesting point. Barry, you have a thought on that?

Dr. Kosofsky: Not every sport is created equal; not every brain is created equal. And we've seen the children and adolescents who have these more protracted syndromes—headache syndromes, mental and physical exertion-induced headaches—are more likely to have had headaches before their concussion and/or have come from families who have headaches. And we've been wrestling with is it just that they're more in touch with their symptoms, or is it really different biology either on a genetic basis when it's familial, and that they're more prone to these changes in blood flow, which we know are the heart of headaches, and that the postconcussive long-term changes in your ability to regulate blood flow to your brain may be why theirs last longer than somebody who resolved.

So, we have think about you may be at greater risk. You can't be a football player because you have a personal or family history of headache, and I'd be a little more conservative. I think in the end, Jim's making the same decision. It's just because that person's headache or post-concussive syndrome lasted longer, and he's making that judgment based on it.

But, there may be a baseline in terms of are you a headache person; do you come from a family with a history of headaches.

20 **Dr. Metz:** From a general pediatric practice sense, what can we do, Jim, to start thinking about preventing concussions from happening in the first place?

Dr. Kinderknecht: Pop Warner Football is the first organization that I know that's really taken active steps to do this. They really mandated rules to the coaches, and that is stressing techniques, not leading with the head. In terms of prevention, probably the best prevention is technique adjustments.

The other thing they've done is they've limited the ability for those coaches to expose. So basically, they shortened the amount of contact time that an individual can have. They've really regulated some of the drills that have been done. So basically, the less you're exposed, the less chance you are to have an injury in terms of a head injury.

What's interesting seeing people at the junior high level, high school level, college level, and pro level, who has the least amount of contact? The professionals. Who has the most contact? The junior high kids. Really what you're trying to do is trying to help the coaches. So, I think at the lower levels, sometimes the techniques that are being taught are not being taught by the right people or the people with the most knowledge.

I think the biggest misnomer is that the equipment is going to eliminate the problem, and Barry talked about this earlier. This is not a direct blow type of thing, and that's the only thing we are able to protect. So, we can protect against skull fractures and facial fractures. What we're never going to be able to protect against is the rotational component of getting hit.

And so, to think that it's ever going to come on the equipment side of things, it just won't. It doesn't fit the injury.

Dr. Metzl: We are inundated every meeting. There are people who are big proponents: "This new generation football helmet will, it'll eliminate concussion. Your chances are so much less because there's this bladder or this thing." The truth is that it's really the function of the brain inside the skull, and they're protecting the outside. Some people have argued that football helmets are actually part of the problem because they give a false sense of security and that we're seeing this injury more commonly now than we did when people were wearing leather helmets because they have no sense of fear when they have a casing around their head, which does little actually to protect the brain.

21 Barry, Jim is arguing for early technique as being one thing and eliminating contact the other. Do you have any other thoughts on this prevention side of stuff?

Dr. Kosofsky: Because the kids are bobble heads, you want to avoid contact. So, no checking in hockey I think is a good idea in the younger kids. They can learn a lot about hockey and a lot about technique and avoid the contact and avoid the collision for the most part if you can, at the younger ages, take away checking.

We also want to keep the size of the kids somewhat homogenous. So, at these younger ages, you see some real big kids and some younger kids. It shouldn't be done by age or grade. Maybe weight or size is the best way to stratify who plays in which division because you don't want to have these discrepancies. Often you'll see in some of the middle school games the tremendous range of kids who have reached puberty and are very muscular and others who are not. And I think that's going to set kids up for injury when there's this mismatch between the size and the strength and the speed of these more mature adolescents and the less mature adolescents.

22 **Dr. Metzl:** If we agree that concussion is often the result of a rotatory force, it's not even a direct blow, but something where you hit the side of your head and you rotate or sometimes the back of your head, that should reason

that muscle strength around your neck, particularly to limit rotational force, somewhat may be effective in prevention. Barry, do you have any thoughts on muscle strength, or does that just anecdotally seem like it should be true, but we don't know it is?

Dr. Kosofsky: It certainly makes sense, but I don't know that anybody's done the test to see if we can control or train athletes in ways that help them with head control that'll have some preventative effect. I think a lot of it though is biologic. When you look at people—short necks, long necks, thick necks, thin necks—and what the musculature is, it's probably going to be less relevant how much you train your neck muscles as opposed to what you were born with.

23 **Dr. Kinderknecht:** When you look at soccer concussions, they rarely occur by hitting the ball. If you see the ball, prepare to hit the ball, you're tensing your neck; you're bracing your body. Almost all concussions in soccer are not you hitting the ball when you know it's coming. It's that inadvertent ball that hits you when you didn't see it. It's the elbow that hit you.

So, we're talking about rules and we're kind of beating up on the sport of football. Barry mentioned hockey, but soccer, a high percentage of the concussions are elbows above shoulder level going for head balls. So, it's not the head ball; it's the elbow to the head by the opponent. So, if you enforce that rule and you keep elbows below shoulder level, which is supposed to be the rule, and needs to be enforced, you're going to eliminate the elbow to the head. You're going to decrease the number of concussions.

I do think that there's something to being braced and prepared. It's the same thing we see in the sport of football. If you're braced and you're making contact, you're less likely. If it's more that blindside hit, there's a clear higher risk.

24 **Dr. Metzl:** As we have grown in our field of sports medicine and we've seen, because of the increased numbers of girls, record numbers of kids participating in sports around the United States, the issue of concussion is one which really every pediatrician, every child health practitioner is being asked about on a routine basis. And I think we've done a much better job at raising awareness about how common these injuries are. And I hope we are doing a better job at teaching people how to take care of these and how to take these injuries seriously, because they certainly are very important for people to think about.

25 This concludes our discussion on concussion. My name is Dr. Jordan Metzl. I'd like to thank my two friends and colleagues, Dr. Barry Kosofsky and Dr. Jim Kinderknecht, for joining me in this very informative and very interesting discussion. Thank you both so much for participating, and thank you PREP Audio and the American Academy of Pediatrics for making this possible.

26 *Narration Close*

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