ECG Screening in Athletes

Announcer: Welcome to Mayo Clinic's ECG Segment: Making Waves, Continuing Medical Education podcast. Join us every other week for a lively discussion on the latest and greatest in the field of electrocardiography. We'll discuss some of the exciting and innovative work happening at Mayo Clinic and beyond with the most brilliant minds in the space and provide valuable insights that can be directly applied to your practice.

Dr. Kashou: Welcome to Mayo Clinic's ECG segment: Making Waves. We're so glad you could join us. Today, we have an exciting episode planned for you as we look at ECG screening of athletes. We'll be joined by someone who has done extensive work on this topic. Before we get into our discussion with our guest, let me provide some background on the topic. The death of any person's life is always a tragic event. It is especially devastating when it occurs unexpectedly to someone considered to be at the peak of their health. And by most measures, otherwise healthy. The majority of these sudden death events are thought to be related to cardiovascular causes. While uncommon, these events can wreck an entire community. For the apparent reasons, ensuring the safety of young and high performance athletes is hardly controversial. Instead, the overshadowing controversy and intense debates surround the methods in doing so, and that brings us to today's episode. We'll focus on ECG screening of athletes including its rationale, its effectiveness, arguments for and against it, as well as opportunities for improving. We have a lot in store for you today, and we are fortunate to have an expert in the field, joining us to help us better understand this important topic. Let me introduce you to our special guest, Dr. Konstantinos Siontis. Dr. Siontis is a senior associate consultant and board certified practicing cardiac electrophysiologist at the Mayo clinic in Rochester, Minnesota, where he has been an assistant professor of medicine since 2018. He completed internal medicine, cardiology and cardiac electrophysiology training at the Mayo clinic and the university of Michigan. He has clinical and research interests in the invasive and noninvasive management of atrial and ventricular arrhythmias, cardiac sarcoidosis, hypertrophic cardiomyopathy, as well as artificial intelligence, applications and cardiology including the use of artificial intelligence, enhanced ECG for detection of cardiovascular disease. Dr. Siontis, what a true honor to have you today. Thank you for joining us.

Dr. Siontis: Thank you. Great to be here. Thank you, Anthony.

Dr. Kashou: As previously mentioned, this is an incredibly important topic to so many of us because it really hits home when any devastating event happens to an athlete. Whether it is a young athlete participating in a high school or college sport, or even a professional athlete who has expectedly been training for years and is at the peak of their performance. And this gets to my first few questions for you. Specifically, why the ECG in particular for screening athletes, in other words what is the rationale for it? And does it improve the diagnostic yield for detecting cardiac disease in athletes?

Dr. Siontis: Good question, Anthony. So as you know, better than anyone the electrocardiogram has so much information that we can gain regarding cardiac health and cardiac disease. You did mention also that the cardiac etiologies are the most common reasons why the sudden death episodes happen in athletes. Thankfully, as you also mentioned, they're very rare. So if you take

about 40,000 athletes a year only 1 of them will have an episode. We want that to be a 0. We don't want it to be any athletes who have to witness them arrest on the field. So, the electrocardiogram really can tell us a lot about electrical disturbances that can predispose to sudden death on the field in athletes, during exercise, but also give us a lot of information about structural disease that predisposes to those events. When we've looked at autopsy studies of athletes who arrested, the main etiologies that we find are hypertrophic cardiomyopathy, a structural disease that predisposes to fatal arrhythmias, especially with exercise. Arrhythmogenic cardiomyopathy, right ventricular cardiomyopathy, also a condition that predisposes to sudden death in athletes. And then secondarily somewhat more infrequent causes such as channelopathies or ventricular pre-excitation syndromes along with somewhat more rare conditions, coronary anomalies and so forth. But those conditions reflect on the electrocardiogram in ways that we can see them. That's why the electrocardiogram is a potential window into cardiac disease and health. Now electrocardiogram alone may not be sufficient. That's why it is usually combined with physical examination and history taking, particularly with emphasis on family history, for those inheritable conditions that can predispose, such as hypertrophic cardiomyopathy or ARVC.

Dr. Kashou: Interesting. And, and so it seems like, you know, these channelopathies a lot of like, you know, long QT syndrome and, you know, hypertrophic, we could see some changes in the cardiac bio signal. I guess there is some value to it, but what is the status today in terms of of using the ECG to screen for these conditions?

Dr. Siontis: Yeah, pretty controversial still. And it's quite discrepant between what the status is in the United States versus Europe. In Europe, it's some historic perspective. Going back to the 1980s, there was a mandatory screening program with ECGs in athletes back in the approximate 1982 that was established in Italy. When they looked at their outcomes for incident citing cardiac death events before and after implementation of the program, they found a pretty significant decline in the sudden cardiac death rates in athletes. That data supported the continued use of ECG as part of the routine, practice, and for pre-participation screening. In addition to history taking and physical examination, the same data didn't really pan out in the United States including some fairly high profile studies here in Minnesota, where we just didn't see that signal. And therefore, the use of electrocardiography for routine pre-participation screening in the U.S is still fairly controversial and not widely accepted. In fact, the professional societies recommend against using the electrocardiogram and in the U.S currently the history taking and physical examination is a standard of care.

Dr. Kashou: It's really interesting, you know, and as you already mentioned, the debates are intense, right? To use the ECG to screen athletes. What are the, the challenges in the controversies that, you know, rely why, you know the ECG for screening is so controversial?

Dr. Siontis: Yeah. So there's several actually. So, in the U.S if you think about the sheer number of people who will need to be screened annually, it's a lot of people. So we're talking about 4 million high school athletes a year, another half a million college athletes, and you have to screen them once a year or once every two years. So, the sheer number of the effort that it takes to acquire the electrocardiogram for those athletes is significant As a downstream effect of that, we need to have qualified interpreters. If not physicians, technicians who can apply the criteria that

we wanna use in athletes specifically for interpretation of that electrocardiogram. To take it a step further there is a fairly significant overlap between what's physiologic adaptation in athletes and the electrophysiologic changes that are in response to that, as well as the changes related to pathology in the heart. So, T-wave inversions can be physiologic and expected in young athletes, usually younger than 16 years of age, especially black athletes, but T-wave inversions can also be seen in ARVC, arrhythmogenic cardiomyopathy. LVH criteria may be met by thin built athletes in the absence of other significant ECG pathology, but LVH can also be present with hypertrophic cardiomyopathy which is essentially the hallmark of the disease. So, as you can see there is a lot of opportunity for false positives. So, the large high number of false positive ECGs has been one of the main concerns, one of the main challenges, why ECG has not been a mainstay approach in the pre-participation setting in the United States. And you can think about the situation where you have an otherwise active very engaged person in a sport, in high school or in college. And then all of a sudden you tell 'em, well your EKG looks abnormal. We have to stop. Don't exercise until we get you to a cardiac MRI, or an echo, or a cardiology specialist who can counsel you on what's going on. It turns out that if you do that if you take a thousand athletes you'll find 30 of them that have some abnormality on the electrocardiogram that needs to be looked into further. So, 30 out of a thousand that's not a small number necessarily when you're talking about healthy people who are out there exercising. Out of those 30, when you look at them in more detail, when you do more testing usually cardiac imaging, stress testing and specialty consultations, 3 of those 30 will have real disease that needs something being done. Meaning usually disqualifying them from exercising or cutting down their exercise intensity. So, for every patient every athlete that you found disease for, there's another 9 athletes that you unnecessarily caused distress, anxiety, unnecessary testing, financial implications, of course. All of that testing is expensive and access to testing may not necessarily be readily available. So, there's a lot of real concerns in the real world, implementation of ECG screening.

Dr. Kashou: You know, I, I do think about it personally from growing up playing sports and here comes Dr. Siontis and you're gonna screen our whole school. And then, you know, you're one of those 30 that is, you know, otherwise healthy, you know participating in all activities. Like we need to look at you. So it's like you mentioned the undue stress the financial components.

Dr. Siontis: Yeah.

Dr. Kashou: But there's also obviously that the real value of not missing these, you know, we talked about the devastation to any community, any family if we lose someone so young that otherwise, you know is healthy and having an otherwise normal life.

Dr. Siontis: Right.

Dr. Kashou: Are there ways that maybe we can improve ways to detect those high risk patients?

Dr. Siontis: Yeah, I think there are and I think there is good promise for the future. The goal, as you mentioned is to really find the people who are high risk and not test unnecessarily the people who may have physiologic changes in the electrocardiogram that doesn't necessarily reflect pathology, but actually reflects the fact that they're athletes. I think that artificial intelligence applications on the electrocardiogram are going to change the landscape of how we're looking at

athletes screening in the near future. As you know, we've developed algorithms for hypertrophic cardiomyopathy detection low ejection fraction, which could have applications in dilated familial cardiomyopathies, ARVC probably coming up in the future. Congenital heart disease conditions that are you know, among the group of diseases that we're looking for to rule out in these athletes. There's also automated interpretation that you Anthony have worked on for the electrocardiogram using AI analytics which can address one of the major challenges which is who's gonna look at those electrocardiograms. So, there's a few ways that AI will eventually change our approach to ECG screening for athletes. Not just by increasing the sensitivity and specificity of the diagnosis, but also the real world implementation addressing those barriers in a scalable way implementing ECG screening in thousands or millions of athletes every year. Another example is the fact that some of these conditions including hypertrophic cardiomyopathy may have completely no manifestation of the electrocardiogram. So HCM, for example, about 10 or 15% of patients have a completely normal electrocardiogram. Those patients, those athletes, we will never find if we just do regular screening with an ECG and manual interpretation. However, AI doesn't care about a normal or abnormal ECG We know that it can detect HCM in normal ECGs as well, or seemingly normal ECGs. So, that is another application where we would not just reduce the number of false positives, but also reduce the number of false negatives with some of those AI algorithms. Of course, no test is perfect. So, there will still be some false positives. I think the number will be lower though. So, I hope that the number will get to an acceptable range where those false positives won't result in such a significant downstream resource utilization, testing, the referral to cardiologist, and unnecessary exclusions from participating.

Dr. Kashou: You know, the artificial intelligence. We see it tremendous value. I'm tremendously impressed by the work on the hypertrophic cardiomyopathy that you've led and you have done with the team here. That's gonna be another episode we have to have you back to do. And then not only that, the implementation, right? Are there barriers? You know, we see the cost as one of them is there a way to minimize that cost? And what does real life application look like?

Dr. Siontis: Yeah. Excellent question. So, especially when you're thinking about the pre-participation screening, you know wanna find ways to do that will minimize the burden to families, athletes, but also make it feasible for those algorithms to be applied in a very wide range of geography, resource settings, and schools and colleges without really having those athletes, those kids, have to come to Mayo clinic or to, you know, XYZ institutions. So, we want to be able to deploy these algorithms with tools that can be directly available to consumers. Portable digital devices that where the person of interest can record their ECG and transmit their digital file, the recording, to a cloud-based service where the AI can be run. You know, those examples are AliveCor devices, even an Apple Watch, a number of different tools that we now have available, and we are exploring. Eventually, I think that utilizing a bundle of algorithms and AI tools integrated into one of those cloud based servers with a tool that's consumer facing directly accessible highly mobile, that can be taken around in a school in a high school or college, and maybe, you know hundreds or thousands of students and athletes can get their ECG tracing done in a day or two. I think that would be the future of ECG screening in athletes.

Dr. Kashou: Yeah. I mean, it's amazing where we're going not only with the software, what we're doing in your leading with these models and the engineers here, but also the hardware, you know

how available now the ability to record a cardiac bio signal and even the ability now to transmit it. I mean, the digitized availability of all these signals is gonna change the landscape of how we do things, but the one thing I did notice you mentioned was, you know, you think of hypertrophic cardiomyopathy, the athletic heart, LVH. It's almost this disease of spectrum that, you know us that even if we look at so many ECGs can sometimes not even tell it apart, but there may be true value that the AI can do that you know, goes beyond what the human can see and it's really exciting work. Yeah.

Dr. Siontis: Exactly. Right. So, the only caveat I would say to that is that we are responsible in training the models to learn what's hypertrophic cardiomyopathy, what's athletes heart, what's physiological adaptation to XYZ stimulus. So, in the end of the day these models are as good as the training was. So, we need to be responsible and thoughtful about the training process. Keeping in mind what the downstream application is going to be. In this particular case, I do think that the hypertrophic cardiomyopathy algorithm should have a very discreet and specific application in the screening of athletes and distinguishing hypertrophic cardiomyopathy from athlete's heart is indeed one of our priorities.

Dr. Kashou: Yeah, it's really exciting work. While the number of athletes experiencing serious underlying cardiac disease is relatively small. The importance of identifying these patients at risk of a fatal event is not difficult for anyone to grasp. Refining screening options and protocols including the proper use of the ECG and inclusion of some of these discussed AI augmented ECG models might improve detection of high risk athletes, warranting further evaluation and even save lives. Dr. Siontis what an incredible opportunity to have you here today. I know I learned a lot and I know we have still a lot more to talk to you about with some of the work you're doing. Thank you so much. I hope you'll join us again.

Dr. Siontis: Thank you so much. Great to be here. Enjoyed the discussion.

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