**Why Wide Complex Tachycardia Differentiation Matters**

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 in which we will dive into wide complex tachycardia differentiation, an important yet difficult topic. Fortunately, we'll be joined by an expert in the field that'll help us tackle it. Let me provide you with a little bit of background on the topic to get you up to speed. Wide complex tachycardias are defined as rhythms with the QRS complex duration of at least 120 milliseconds and a ventricular rate of a hundred beats per minute or more in adults. These rhythms can either have a supraventricular or a ventricular origin. While a supraventricular origin is generally benign, a ventricular origin suggest ventricular tachycardia, which can be potentially lethal. Therefore, determining whether the wide complex tachycardia origin is coming from above the ventricles or in the ventricles really helps determine immediate therapeutic interventions in the ensuing clinical workup. Due to the undeniable clinical importance of wide complex tachycardia differentiation, researchers have worked tirelessly to create solutions to assist clinicians in performing this difficult task. Since the 1960s, multiple manually applied ECG algorithms have been proposed. These approaches leverage pathophysiologic principles associated with ventricular tachycardia to get to an accurate diagnosis using the ECG. However, despite these proposed methods, this task is not as easy as it sounds, especially in the acute setting when the wide complex tachycardia presents and management decisions have to be made. Today, we're gonna dive into this topic in much greater detail. We're gonna be looking at why this problem is clinically important. We're gonna look at the conventional means to differentiate wide complex tachycardias and we're gonna take a look at what the future holds to solving this problem. Our expert joining us today is no stranger to us or our research team. Today we have Dr. Adam May with us. Dr. May is a cardiac intensivist and assistant professor of medicine at Washington University School of Medicine in St. Louis. Dr. May's research interests are related to the discovery, the development and refinement of innovative processes to enhance the diagnostic capabilities of automated ECG interpretation. More specifically, his work has led to the development of automated methods designed to accurately differentiate wide complex tachycardias, what we're gonna be discussing today. His forthcoming research seeks to leverage the diagnostic capabilities of artificial intelligence techniques to better facilitate accurate rhythm analysis. Dr. May, thank you for joining us today. What an important subject we have in front of us. I've been really looking forward to discussing this with you. Thank you.

Dr. May: Thank you very much, Anthony. It's my pleasure to be here. Thank you.

Dr. Kashou: So, because you know, I know you quite well, but I think you may be a new voice to our audience, can you share a little bit about, you know, yourself, you know, how you got involved in this work and you know, why you actually think it's so important.

Dr. May: Thank you. Well, you know, it's starting to end up being quite a long history with me at this point. But it all began in my very beginning of my clinical training as a medical student. There was a clinician, a hospitalist, at the Hines VA in Chicago who took the time to teach us residents and us medical students, which I was at the time, various abnormal heart rhythms. And the one that came up was a wide complex tachycardia. And everybody said VT, VT, VT. That's exactly what it is. And he made the point that, yeah, you have to be especially careful with that diagnosis just by default because other forms of heart rhythm that can cause a wide complex tachycardia. And it all started there. I found that to be sort of a unique problem at the time. And then I was confronted with this actual problem as a resident when I was in the cardiac ICU at the Mayo Clinic. Me and Jorge Brendasalazar were the resident and the fellow at the time and we were confronted with this problem. And, you know, the initial impression of us is that we didn't really understand what the actual rhythm was at the time that ECG was recorded. But then we referred to a couple of algorithms and I think it was the Vereckei aVR algorithm, the first step, a dominant R wave and lead aVR clinched the diagnosis of ventricular tachycardia. And from that point I was hooked. And, you know, to the second part of your question, why do I think this is so important? Well, it has a lot to do with patient triage. Where are you gonna send these patients? Because as you mentioned earlier, Anthony, you know, it could be a potentially benign rhythm or something that is extraordinarily serious. So where are you gonna send these patients? Are they gonna go to the hospital floor? Are you gonna send them home? Are you gonna admit them to the cardiac ICU for further care and workup? The other thing is, is when you are addressing this rhythm, and let's say you decide upon it being VT, ventricular tachycardia, you sort of have to think about, well, why is VT there to begin with? And because of that question, why, you are liable and likely to pursue a more advanced diagnostic workup. Things that come to my mind include echocardiogram, cardiac MRI, maybe a coronary angiogram, potential an EP study.

Dr. Kashou: And so, you know, Adam, what I'm hearing and not to cut you off is the clinical implications are important at the time that you see this rhythm. And so let's say that if they're important, you know, when you're differentiating, essentially VT or not, what are the clinical implications if you diagnose, say a VT, when it's actually a supraventricular rhythm or vice versa.

Dr. May: I'm glad you mentioned that because the controverse has some immediate implications. You should never diagnose a super, or a ventricular tachycardia as a supraventricular tachycardia, because that could actually lead to faulty medication choices that could be disastrous for the patient. But the controverse has some later downstream effects. You might actually provide these patients automatic cardio defibrillator when they wouldn't otherwise qualify for. You actually might proceed with a diagnostic workup that includes a base examination such as an EP study, or even a coronary angiogram, all of which have financial implications, but even risk that can be unduly exposed to the patient.

Dr. Kashou: Interesting. And so let's just kind of, you're a cardiac intensivist, let's put you back in your cardiac ICU and say that, you know, you have a resident or fellow, you know, in that position that you were, that comes to you with an ECG that shows a wide complex tachycardia. Like so, as now the consultant, the boss, you know, what do you do next? Are there common methods or tools, you mentioned the Vereckei, are there things? What is currently available?

Dr. May: Yeah. So as you mentioned earlier, Anthony, we have at our disposal, decades upon decades of great clinical research. And from that research, we have a number of manual algorithms to which we can apply to every circumstance a wide complex tachycardia shows up. So there's many great algorithms out there. And they span from multi-step algorithms, scoring systems, individual criteria. The list can go on and on, but some of the ones just for your audience, the Brugada algorithm is a common and heavily utilized one, Vereckei's aVR is another very popular one, lead II R-wave to peak time algorithm is very neat, and then we also have the VT score, which is something more recent that actually can be quite helpful in terms of distinguishing one rhythm and the other.

Dr. Kashou: And so you, you know, again, going back to the situation, you have a colleague, you know, resident, fellow brings you this, you go through those methods and, my gosh, what do you? Do you like, you probably have them known by heart, but, you know, say you're not someone that's doing research on this all the time.

Dr. May: Yeah.

Dr. Kashou: You know, what do you do? Do you search them on the internet? And then, you know, what are kind of the limitations you see, you know, with this?

Dr. May: Yeah, absolutely. So you're sorta hitting the nail on the head in terms of kind of the biggest challenges that we are sort of faced with. So for me, this is an area of interest of mine. I do a lot of research in this area. I happen to love these algorithms and I do know them by heart. So every time this ECG presents itself in my clinical practice or if there's an occasion to teach residents, I apply all the algorithms, which is actually, they're numerable in fact, but I apply all the algorithms. Sometimes the algorithm will put you, it puts you towards the right diagnosis. Sometimes it may fall short to actually establishing the correct diagnosis, but I apply all of them. And the reason I do that is I think it provides you the best opportunity to arrive at the correct diagnosis. It may not necessarily be practical for people that don't have them, you know, known by heart, but what typical providers, you know, people that don't have an expertise in this area, what they're sort of need to do is practice these methods, understand them in more detail and when the occasion comes, they have to actually summon forth the appropriate reference materials and diligently apply the algorithms as they have been published.

Dr. Kashou: So, you know, I guess the first thing I'm saying is, A, you're presented with a problem that has to be dealt with in a rather urgent manner yet you have, say, a fellow or someone back in the years in your position now coming to you, or maybe you're not around, say you're home and this is the middle of the night. You're saying that, you know, one, they have to, A, know which algorithms to look up and what is available. Not even, you know, I guess blindly knowing their diagnostic performance. There's also the reliance on their competency as an interpreter. You know, like, do they know what is, you know, some of them, the RS interval? Do they know, you know, ventricular activation, the, you know, excursion time? So, excursion velocity in some of these. So all of these, and that's, you know, making sure that they have that, you know, referencing the right thing, not even getting into some of the limitations probably of the diagnostic methods that are proposed. So is that what I'm hearing?

Dr. May: Yeah. So, absolutely. That's what you're hearing here, Anthony. This is an incredibly complex and challenging task to accomplish in clinical practice And developing an expertise in this subject matter is exceptionally challenging. None of this expertise that you and I have arrived overnight. This takes a lot of painstaking, diligent work and practice to be prepared for when these occasions do happen. So, this is kind of the common scenario that can happen amongst people that are presented with this type of rhythm. First you recognize it's a wide complex tachycardia, and then someone asks you, "Well, is this VT or not?" And then you break out in a cold sweat because you can't really establish any sort of confidence to the fact that it's a dangerous heart rhythm or not. And that's a very peculiar situation for you as a clinician to be in, but it's also even a more precarious situation for our patients. What we're here to do, provide the best care that we can. And here we are confronted with decades upon decades old diagnostic dilemma, to which that we're still struggling with. It's actually amazing to think about it from that perspective, but that is how things currently stand right now.

Dr. Kashou: Well, you know, Dr. May, if I were, you know, shown this as a medical student and probably, you know, early into residency, and I hear it's a regular fast, wide rhythm, you know, you just think of VT.

Dr. May: Right.

Dr. Kashou: And so I guess it's the first thing knowing that it could be something else too. And not only that, like your management completely changes. So, you know, and this is kind of what I love doing. So it's like, man, I think of how much time I spend in this field that, you know, if I'm a non-heart rhythm and I'm still growing and learning, but it's, you feel for those that, and the patients that we deliver the care for. And so, you know, a lot of the work that you're doing and that we're working on is really solving this problem. Is it VT or not? And so maybe you could share a little bit of some of these automated tools of differentiating wide complex tachycardias.

Dr. May: Yeah. Happy to. So Anthony, a lot of this research that I've been engaged with, you've been engaged with, it really stems from the challenges and clinical importance relating to this subject matter. And under ideal circumstances, this is done in a automated, timely and very accurate in a reliable fashion. And what I've dedicated, you know, many years to, and as have you, is sort of discovering new novel solutions that can be practical, reliable, and accurate, and really help this current situation, this diagnostic dilemma, for not only our providers to establish the right diagnosis, but for our patients. So we've been involved with developing automated tools that could be applied automatically to standard computerized ECG interpretation software. Those include the wide complex tachycardia formula, the wide complex tachycardia formula number two, and then also the VT prediction model. Now these are all models that could be immediately and automatically applied using computerized ECG interpretation software. And the intent behind these methods is to facilitate accurate diagnosis by serving as a diagnostic adjunct for clinicians to use.

Dr. Kashou: And so maybe you could say, you know, tell us a little bit of, you know. Again, back to our story, the fellow, the resident, trainee comes to you, you know, needing a little assistance to provide that, to make sure the care that we deliver to our patients is the right care.

You're saying now that these automated means, so what do they do? How does that kind of look like, what would the resident or a trainee get if these were integrated clinically?

Dr. May: So, yeah, that's a great question. So when we're talking about automated methods, you certainly can use them in two different ways. One, you could just have an outright diagnosis that's sort of provided to the clinician. Could be a VT or a SVT. The other avenue that we're gonna take is actually establishing a likelihood of the diagnosis. Now, if you have a binary diagnosis, you know, it's either one versus the other, there's no in between, that sort of can be limited because not every test is perfect, not every algorithm's perfect. And I think that we seen that in alternative manual approaches. If you have an absolute diagnosis, no questions asked, there's gonna be a certain percentage that it's actually inaccurate. So what we are envisioning is actually providing to the clinician the likelihood of an underlying diagnosis. For example, let's say we get a wide complex tachycardia ECG and on the actual ECG paper, you have a sort of percent probability of it actually being VT. So if it's something that the algorithm predicts to be a high profitability of VT, let's say 99.9%, the clinician will see the ECG, see the wide complex tachycardia and then see the automated prediction of what the actual rhythm most likely is. And I think that could be very useful for the clinician because they could use other clinical judgment, other diagnostic tools to actually help arrive at the right diagnosis.

Dr. Kashou: Amazing. So almost a way, you get the ECG, it provides some prediction, say, here's a wide complex tachycardia ECG, it's showing 98%. Okay, this is most likely VT. And then they act immediately on that. The other say, it's like 60%, and I guess you would use your clinical judgment, you know, does the patient have a prior MI or some scarring focus that may setting this off? Is that kind of what you're saying?

Dr. May: Absolutely. So if you are sort of at the both ends of the spectrum, in terms of likelihood, let's say you're at 0% or 1% probability of VT, I think you could be pretty comfortable that that's gonna be an SVT diagnosis. And if you're on the 90% plus likelihood of VT, I think you'd be, can be fairly confident that that's most likely gonna be a VT. But then there's that area in between. And according to our automated approaches, that's gonna be a small fraction, but it's a worthy fraction, or it's a substantial fraction to which you have to strongly consider alternative diagnoses, even if it's more heavily weighted towards VT versus not. So in that occasion, I would recommend, with the use of these automated approaches, would be using kind of the standard go-to methods, manual methods, such as the Brugada algorithm, Vereckei's aVR algorithm to help establish the correct diagnosis.

Dr. Kashou: All right. So again, story. ECG comes to me, wide complex. I get this prediction, you know, and then from that prediction, I either make decisions. It removes, I guess, this prediction removes my competency in interpreting ECGs. It produces a kind of reproducible result because it's not something, it's a computer generated and there's no bias, right? You know, no human error or bias. And then after I had that, I would kind of use my clinical approach or acumen and maybe use a multi-step algorithm such as the limb lead, Vereckei or Brugada, or maybe, you know, some algorithms like the single lead one, the R-wave to peak time, or even a point scoring system. But essentially, you'd have kind of a prediction to start off with and then use your clinical judgment after. Am I kind of getting the story correct?

Dr. May: Absolutely. That is a story. So what we are hoping to develop and deliver to clinicians is a tool that's going to help them arrive at the right diagnosis. It won't be a situation, at least for the foreseeable future, that the clinician is replaced entirely. I think our goal and the ultimate ideal goal would be to have our tool really enhance the clinician and make their diagnoses the best they can be at the present moment, irrespective of their ECG expertise and shortcomings, in terms of interpretation of ECGs.

Dr. Kashou: You know, I think of like all of our work with artificial intelligence and kind of using that to, you know, enhance our interpretation, some clinical diagnostic, you know, things that we're seeing that we're like, "Wow, the ECG is giving us this." I think the main message is, correct me if I'm wrong is, you're not saying this replaces clinicians, but serves as an adjunct to support their diagnosis in the next steps in management. Is that correct?

Dr. May: Absolutely. That is correct. And I think tools helping providers arrive at the correct diagnosis is the future. And I think, you know, I think it sort of dovetails to the concept that, you know, critical thinking and assimilation of all information and context can't be replaced by machine. And it really boils down to a great clinician appropriately using the diagnostic tools available to them.

Dr. Kashou: Now I must ask, you know, you're doing these tools, they're automated and people are gonna get it. Have you compared them to kind of the conventional manual algorithms that exist today? Do you plan to do that? What's that, you know, what's that performance look like?

Dr. May: Yeah. So this is sort of diving into sort of our plans for research. So we will be comparing manual diagnostic methods to the performance, diagnostics performance, of our automated algorithms. I think that's gonna be a very interesting study we're developing currently at both of our institutions. And the other thing that, an area of research that I think it will be very interesting once it comes out is sort of the improvement in diagnostic performance with the application of these methods. And I think that's gonna be very, very interesting to see the results of that. And I'm very excited about this current work that you and I are both involved with because that is the end game right there.

Dr. Kashou: I think you said it. Two prongs. You know, how does it, you know, compare to the current stuff and then the other, and does it actually help providers improve their accuracy, their confidence in making the right diagnosis? I think that's two amazing things. I'm really excited to see what that shows. You know, one final question I have, you know, most clinicians, you know, don't spend all day thinking about how are we gonna solve this, maybe like you and myself. You know, so what approach would you recommend medical providers use today to differentiate wide complex tachycardia?

Dr. May: Yeah, that is a great question, Anthony. So, I would say being prepared for these occasions is the best thing that we can do as clinicians. I would really understand the reference materials, read the reference materials. There's some great review articles out there that people can sink their teeth into. I would say that having these materials available to you for when these occasions happen, and they will happen, would be a very, very prudent approach. And then the other thing is, is I think people should practice. ECG is a skill. It's not a knowledge per se, but it's

actually an applied skill. And the only way you can get good at a skill is the practice. So I would encourage people to practice these methods on wide complex tachycardias, either through their own ECG laboratory, if there's a collection of them or using ECGs from online resources. I think if you do that, they'll set you up and provide the best opportunity for you to do the right thing as a clinician for your patient when that occasion presents itself.

Dr. Kashou: Wonderful. Yeah, I could an echo that anymore. I think we could all use extra practice. Still trying to learn each day. Despite the ever-growing arsenal of manual methods proposed to differentiate wide complex tachycardias, this remains a difficult task for clinicians, especially non-heart rhythm experts. Today we learned that accurate differentiation impacts immediate patient care. We discuss conventional manual methods used to differentiate these rhythms and some of their limitations and we got a glimpse into some of the work on the horizon to solve this problem. Dr. May, what exciting work you are involved in and I'm excited to see what the future holds. Thank you for taking your time to join us today. We look forward to having you back in the future. It's been a true pleasure.

Dr. May: Thank you Anthony. The pleasure is mine. Thank you.

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