ECG Features and Principles to Differentiate Wide Complex Tachycardias

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 a fascinating episode planned for you as we discuss wide complex tachycardias, focusing on electrophysiologic properties that can help us determine the tachy arrhythmia's site of origin. We're fortunate to have an expert clinician in this field to discuss, and help us better understand this important clinical topic. So let's get started. Now, in a previous episode we discussed what defines a wide complex tachycardia? The importance of arriving at a correct wide complex tachycardia diagnosis. And we also discussed the underlying motivation for the ever expanding abundance of manually applied and automated wide complex tachycardia differentiation methods. Now, I would highly recommend you go back and listen to that episode if you haven't already. In this episode, we're gonna dive into the underpinning principles behind the various differentiation algorithms and criteria that help clinicians to properly distinguish wide complex tachycardias. And we're fortunate to have Dr. Adam May join us again to further discuss this topic. 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 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. And his forthcoming research seeks to leverage the diagnostic capabilities of AI or artificial intelligence techniques to better facilitate accurate rhythm analysis. Dr. May thank you so much for joining us today.

Dr. May: Thank you, Anthony pleasure to be here.

Dr. Kashou: You know, so last time you were here we discussed the clinical implications of accurate wide complex tachycardia differentiation, and that determining whether it was a super ventricular or ventricular in origin was really critical. And maybe you could share some as we build on that topic, some of the underlying electrophysiologic features that you look for when trying to determine the site of origin of a wide complex tachy arrhythmia using the 12-lead ECG.

Dr. May: Excellent question, Anthony. Now, wide complex tachycardia differentiation is a very, very big subject. And there currently exists many criteria and many years of research in developing those criteria. Basically a large number of criteria relate to leveraging the underlying electrophysiology principles, that help you differentiate between VT and SVT. And it essentially boils down to about seven different concepts. The first one being is AV dissociation. This term is thrown around a lot. I'm sure we'll be able to discuss more of this. Then there's also the collective category of morphologic criteria. Again, a big topic in of itself. QRS duration has value. The concept of chest lead concordance. I hope we spend some time discussing this. And then also QRS access. In addition to which there's a more concept or a more difficult concept, that being

differences in ventricular activation velocity at the onset of the QRS, in comparison to the termination of the QRS, during ventricular depolarization And of course evaluating the presence and or differences between a baseline ECG and the wide complex tachycardia itself.

Dr. Kashou: So quite a few things that you probably apply routinely to narrow in, or even help you. I mean, we're talking about some of these features on the ECG, but we're kind of lacking to include also the patient specific features, the clinical context, and some of the other diagnostic you know, features and tools that we have to narrow in that. Now you highlighted and mentioned AV dissociation. So atrial ventricular, or AV dissociation, and we hear of this as the most specific feature to distinguish VT, and a super ventricular wide complex tachycardia. Now in clinical practice you always hear this thrown around, as you've mentioned can you share a little more about what this concept is? And you know, how we may see this manifest on the ECG?

Dr. May: Yeah, first it's important to know that AV dissociation is an incredibly important criteria to help you distinguish between VT and SVT. If AV dissociation is present, you can be assuredly confident that VT is actually on the ECG. Now this value was first characterized all the way back in 1978, by the great Hein Wellins. Now, you know, nearly like of five decades ago in practice, it's a highly specific criteria. In other words, if you have it, you can be very confident that VT is present. And as such, it's been incorporated into many different manual algorithms. The main drawback with this criterion is that it's not as sensitive as we would hope it would be. It's found in about 20% of all ECGs, or wide complex tachycardia ECGs that actually have VT. And really what AV dissociation is, is really identifying independence, atrial and ventricular activity. Now this can manifest in a variety of ways. One being capture beats, where the super ventricular impulse actually could... Is appropriately timed and actually captures the entire depolarization of the ventricle. Then there's fusion beats which are where the super ventricular impulse and the ventricular impulse collide to create sort of a a hybrid QRS complex that shares properties of the VT itself, but also the baseline ECG. And then we all heard of dissociated P waves, which I find this to be very challenging, but in practice, you can find them in many cases. And you're essentially looking for P wave activity, sort of nestled in and interspersed between the QRS complexes. Now, any of these features if you do find that on your 12-lead ECG, you can be very confident that that VT is present. However, if they're not present you can't say that SVT is the diagnosis. I think that is an important point to make about this. But overall AV dissociation is great. I use it routinely every time I'm encountered with these wide complex rhythms, and it's gained a lot of support and use over the years.

Dr. Kashou: It's really fascinating, 'cause I think you're right. We think of, you know, AV dissociation, we've talked to... It's the most specific, but it's really not sensitive. We don't see it often. And often when it's taught, it's more in the context of looking for those dissociated P waves, you know. Is there any deviation maybe in the ST segment or T wave, or even in the QRS that's hinting towards it, but you also mentioned, which are helpful, and we don't usually, you know, learn about are some of these surrogate markers of AV dissociation such as fusion beats, where the atrial ventricular, you know wavefronts are colliding or capture beats where you have atrial impulsing, engaging into the ventricular system. And so those are important. And I think important for our viewers to know these markers that could highlight, you know, the AV dissociation. So if you see a wide complex arrhythmia, with fusion beats, you know, think that this is a sign of that and may hint towards VT, really important. And now earlier you mentioned

these morphologic criteria right? And there's a lot of these. What do you really mean by morphologic criteria? And is this helpful in differentiating? How do we use it?

Dr. May: Yeah, so morphologic criteria is a difficult kind of catchall phrase for a very complex process of interpreting a 12-lead ECG. Basically it's a collective combination of criteria brought forth separately, by some of our early pioneers within this space. People like Hein Wellens, Marriott, Kinwal, Josephson, they all contributed separately to what we now call, the Morphologic Criteria. Now morphologic criteria essentially evaluate the QRS complex at specif leads. That being V1, V2 and also V6. And the underlying purpose of morphologic criteria is to determine whether the QRS is consistent, or inconsistent with aberrant. That being left bundle branch block or right bundle branch block. Now, if the QRS complex is consistent with aberrancy, it is determined to be a typical morphology consistent with super ventricular wide complex tachycardia or SVT. Now, if it's inconsistent with aberrancy, it is assigned atypical morphology, that being more consistent with VT. Now, I think these criteria are very helpful but there's lots of details to consider every time you apply them. And there are some limitations, especially for certain VT diagnoses that share a lot of the features of aberrancy, specifically the circular VT and bundle branch reentry

Dr. Kashou: Yeah. Is really a good in... I mean you mentioned morphologic criteria. We know there's a number of them, whether it's the atypical right or left bundle, and just recognizing them first, knowing what a typical pattern is and, you know, atypical just to give an example and you correct me if I'm wrong, you know, typically we see an RSR prime that right bundle branch block pattern in the right precordial leads. However, typically that initial R is smaller than the R prime.

Dr. May: Absolutely.

Dr. Kashou: I guess, you know, an atypical characteristic would be where the initial R is greater in amplitude than the R prime. Is that one pattern you think about?

Dr. May: Absolutely that is one of the patterns to look for. But again, as I mentioned, there's lots of different patterns that can be inconsistent with aberrancy and more consistent with ventricular tachycardia. Another example, if you're talking about V1 and V2, would be a QR pattern. So if you have a wide complex tachycardia with a QR pattern in leads V1 and V2, that would favor ventricular tachycardia.

Dr. Kashou: Great, great. Now that's wonderful. Now another thing you hinted on early on was the chest lead concordance as criterion to differentiate. How do you actually define this? And what is the underlying electrophysiologic basis and practical value for this type of criterion?

Dr. May: Yeah, great question. I love chest lead concordance. It's one of my most favorite types of wide complex tachycardia differentiation criteria. And it's very highly specific for VT. If you can determine that it is present. Now, according to the strict definition of concordance, concordance is present if the QRS complexes are entirely upright or downward oriented, and leads V1 through V6, or the chest leads. Now positive concordance is present. If there's a dominant R wave in all leads of the precordial, or V1 through V6. Now, negative concordance

would be present if there is a QS pattern in every single one of those leads. Being V1 through V6. Now, if you have positive concordance it is most likely related to ventricular tachycardia arising from a base, posterior basal portion of the left ventricle. If negative concordance is present, that is most likely VT originating from the anterior apical left ventricle. Now, there are exceptions to these rules now, and it's quite possible that certain SVTs actually bring about positive or negative concordance. However, this is very unusual and is usually in the case of positive concordance would be due to SVT, due to an accessory pathway actually bringing about that wide complex tachycardia.

Dr. Kashou: Interesting. So, I mean, we've covered already quite a few and it's like you're mentioning this is one of your favorite, the ones you look for, the chest lead concordance, you mentioned AV dissociation, we talked about the morphologic features. And so this is kind of that arsenal of things you go when you're evaluating ECG to differentiate ventricular or super ventricular origin. Now the final concept I wanna bring about and chat about, is the wide complex ECG in that baseline comparison. Why, you know, this is talked about. Why is it so valuable?

Dr. May: Yeah. So this is a very important determination to make every time you're confronted with a wide complex tachycardia. And it can be very useful in determining if it's a super ventricular tachycardia or ventricular tachycardia. Now this comparison, the purpose of which, is really to identify the difference compared to the baseline ECGs. Now, if there is a big difference, VT is more likely. If there's a smaller difference with this comparison, SVT is more likely. Now the underlying electrophysiology behind this relates to the degree to which the wide complex tachycardia uses the same depolarization pattern as the baseline ECG. So for SVTs or super ventricular wide complex tachycardia , in most cases they're using entirely or partially the same depolarization pathways in the heart. Ventricular tachycardia is different. Now, VT usually brings about very different wavefronts to depolarize the left ventricle, and that leads to big differences between the ventricular tachycardia and also the baseline ECG in of itself. Now, this concept was leveraged in the past, starting in the late 1980s and in early 1990s, by a couple different authors, that being Dongus and Griffith. Now, Dongus was the first essentially show that QRS morphology changes, large changes would be more consistent with VT as opposed to SVT. And Griffith brought about the idea of QRS axis shifts, being greater than 40 degrees in shift, that would be more consistent with ventricular tachycardia.

Dr. Kashou: It's really interesting. And as you mentioned kind of engaging the conduction system, one that's more similar, more likely to be more of a super ventricular origin, whereas one less similar bigger deviations, deltas thinking more VT. And you think about the activation velocity that you mentioned earlier, but I really wanna talk a little bit about your recent work that leverages this concept of the baseline and the wide complex ECG comparison. Can you share a little bit about that?

Dr. May: Well, again, Anthony, thank you for allowing me to talk about a subject that's very near and dear to my heart. So our work essentially leverages this idea in such a way where we can directly quantify the degree of change between the wide complex tachycardia and also the baseline ECG. And we can essentially get this direct quantification using the numbers that are embedded into ECG interpretation software. Now we derive these sort of differences and put

them into features that can be put into mathematical models, such as logistic regression, or other forms of machine learning. And we can essentially create a model that can be automated, and leverage this key principle to arrive at a probability or an accurate classification of what the underlying rhythm is. Now, certain models that we made in the past or in recent years, include the wide complex tachycardia formula, the VT prediction model, and also the wide complex tachycardia formula too. Now, these models are high performing models and they essentially can be integrated into commercially available ECG interpretation software. And it is our hope that these type of models get created into these type of software programs to actually directly help clinicians decipher what the actual wide complex tachycardia is.

Dr. Kashou: It's so exciting. I mean, I want to have you back to talk about not only, you know, some of the algorithm developments of the manual methods, the multi-step, and all those, love to chat with you about that at some point. But also to learn more about these automated methods, because the idea of having a prediction of whether one is a ventricular, or super ventricular source, in addition to using clinical context, but to have that immediately available, it sounds remarkable because we know a lot of the limitations that rely on you know, the interpreter, right? You mention all these, and you're an expert in this field. So you have them all. You're probably applying all of them, but for someone you know, on the front lines is not a heart rhythm expert. They may not have the tools or even the competency in being able to interpret these. So I'm excited to learn more. Hopefully we'll have you back to share more about that. It's such exciting work. Yeah.

Dr. May: Well, happy to Anthony. Yeah, anytime. Anytime.

Dr. Kashou: Well, accurate and timely wide complex tachycardia differentiation is important for clinical decision making. However, this is not an easy task. We saw that today. Now being familiar with and being able to apply electrophysiologic properties and these features that help discriminate ventricular and super ventricular tachy arrhythmias on the ECG can help you arrive to the correct diagnosis and help your patient. Now, hopefully today's episode was informative a practical side, and added a couple more tools to your wide complex tachycardia differentiation arsenal. Dr. May what an important and difficult topic. Thank you for sharing some practical tips for our audience, and taking time out of your day to join us. It's really been a true pleasure.

Dr. May: Agreed. Thank you very much, Anthony.

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