Common Errors in ECG Interpretation – that can Easily Be Corrected

Announcer - Welcome to Mayo Clinic's ECG segment Making Waves Continuing medical education podcast. Join us 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. In this episode, we delve into how learners can become adept in the nuance scale of ECG interpretation. We'll examine the intricacies of teaching ECG interpretation and discuss common errors that can arise and that can easily be fixed. We're fortunate to have Dr. Ken Grauer with us today, who is Professor Emeritus in Family Medicine following his residency training in family medicine. He worked for two years in a busy emergency department in South Florida before moving to Gainesville, Florida, where he was full-time faculty in the University of Florida Family Medicine residency program for his 30 year career until retiring from his academic practice in 2010. Dr. Grauer has written over 10 books on ECG and arrhythmia interpretation, presented hundreds of talks in workshops locally and nationally on ECG interpretation and other cardiology topics over his career, and has been as active as ever since retiring. He has over 3 million views on his own ECG blog. He's an associate editor and active contributor to Dr. Steven Smith's ECG blog, as well as answers numerous daily queries addressed to him on any of the many international ECG internet forums that he regularly contributes to Dr. Grauer. What an honor, and we're so lucky to have you joining us today.

Dr. Grauer - Thank you, Anthony. It's pleasure to be here.

Dr. Kashou - Well, you know, I was looking forward to this. You, you know, you and I have gone back and forth and talked about the importance of this skill and to finally get a chance to sit down with you and talk more. Maybe we could start with your background. Dr. Grauer, tell me how does a family physician, you know, I'm going through my cardiology training, but you're as a family physician, how do you get so good at this skill?

Dr. Grauer - As mentioned, my training is in family medicine. I am not a cardiologist. I guess it's a lot of practice. So from my very first day of medical school, I just became fascinated by electrocardiograms, by interpreting ECGs. I dare say this was back in 1970, which puts me at over half of a century of experience with ECGs, lots of practice, tremendous number of tracings, always getting clinical follow-up. And then as I began working in family medicine as full-time, faculty, lots of teaching with medical students, I taught the medical student ECG course for over 20 years, taught residents for over 30 years, and then things really took off after I retired with the internet. There are literally, as you know, hundreds of thousands of providers worldwide on these ECG internet forums, and I get people sending me their most difficult stuff that I have to learn as I see it. But lots and lots of practice, that's how it occurs. I can move into our topic, which is really about what I call errors. I'm calling errors certain practice habits, and that may sound a bit harsh, that's not my intention, but basically after 40 plus years of active teaching in the topic, I've just

noticed that there are lot of areas where learners experienced providers, sometimes experts in the practice, there's some common things that they do. There's some very simple fixes of oversights that can really correct things and can really improve their ECG interpretation ability. So my goal in this podcast is really to go over some of what I've picked up in 40 years as an interpreter, as somebody who also mentors others that can both improve the time efficiency of interpretation as well as the accuracy. So I'll start out by just saying I'm sent to tracing. This could be many different ways that tracing gets to me. Email on an internet site and first error, and I'll use the words errors. The first error is there's either no history or there's a history that doesn't really tell me what I need to know. Sometimes I get sent tracings and people don't even tell me the age of the patient or there's the opposite where what they send me is a whole list of things of the patient's entire medical history without necessarily even getting to what's really relevant for interpreting the ECG. So the first error that I would say is either giving too much or too little for optimal clinical interpretation. I'll mention that I also often, as you probably do also get a pretty quick idea of the ECG interpretation ability of the person who's presenting to me. Most clinicians in active practice, whether they're paramedics, physicians, cardiologists, emergency physicians, they don't have a whole lot of extra time nurses on a floor, physicians in a practice. So I'll emphasize that the relevant history should be brief, no more than two to three lines is optimal for me. I need the age of the patient. I'd like to know male or female because that does enter into some of the entities that we get to interpret. I wanna know why the ECG was done. If the patient's having symptoms, all of the things for standard history, when did the symptoms begin? Let's say chest pain, how long does the chest pain last? Is it constant increasing, decreasing? And any thought to anything else that might be relevant? The reason for knowing the history, and I emphasize that the history is key to optimal clinical interpretation, is you can take the identical ECG and depending on the history, your interpretation might be very, very different. So some examples of this, take a previously healthy middle-aged man, he calls EMS for new chest pain. That awoken from sleep chest pain has been constant for the past two hours. That's all I need to know. It's really all I wanna know. I know that I'm interpreting that ECG for the possibility of acute ischemia and or ongoing infarction. I know with a history like that, that the patient is immediately placed within a higher prevalency group for having an acute event. So that means that we're really starting out with the realization that we need to rule out an acute event rather than the opposite. So often when I interact with clinicians, they have an initial ECG that perhaps doesn't show very much the patient's chest pain, maybe it's a little bit less and then they get lax in terms of the follow-up. Maybe not repeat an electrocardiogram for another couple of hours or so. If the history is a patient of the right age, sounds cardiac, it's new onset, I have to rule out an acute event and I can't let my guard down, I'll be getting repeat tracings following troponins if they're an emergency department and other related parameters. So how about if the severe chest pain woke this patient up from sleep, but by the time the patient finds EMS arriving at their house, the chest pain is less or it's totally gone. So we need to be aware of what's known as a pseudo normalization period. So patient has acute onset of chest pain, the ST segments go up and then perhaps the chest pain is relieved and the ST segments go down. And ultimately there's T-wave inversion. What happens in between the ST segment elevation and the T-wave inversion, if you get the patient sometime in between and do an electrocardiogram, it may look relatively normal. Other examples of the use of a brief and relevant history, say you have a younger patient, the male in his twenties or thirties, and we know in 2023 that you can have acute infarction even in your twenties, but it's less common, particularly if the patient is previously healthy than if we have an older individual with lots of risk factors. So say you have a younger adult male, relatively lower prevalence group for an acute infarction and there are peak T-waves on the electrocardiogram, so they're taller than you're used to

usually seeing for T-waves, and they're more peak than they're usually seeing. And it helps to know that we're dealing with a lower prevalence group so that it's less likely to be an acute infarction. Doesn't rule it out, but less likely and more likely that it could be some type of repolarization variant. On the other hand, say you see the identical looking T-waves more peaked, a little bit taller in a patient who does present with new onset cardiac sounding chest pain, then you have to be much more concerned about hyper QT waves. Now let's go back to this younger adult, taller than expected T-waves more peaked. Is there a recent viral infection? Could this patient have myocarditis? So whereas an acute myocardial infarction from coronary occlusion is less likely, you can still get all of the same types of changes on an ECG with acute myocarditis. Another example of the history, say you've got an older patient who presents with a fainting spell bradycardia, tell me please, is this patient on any rate slowing medications? That's often something that's not thought of. Other examples in which the history can be important. Say you see a bruga pattern in the anterior leads and the ECG otherwise doesn't look all that abnormal. Now this could be Brugada phenocopy, that means you get a frank Brugada ECG change that looks identical to what a Brugada syndrome may look like that's due to something else. And there's a list of the something elses. In my experience, the two most common something elses are fever and hyperkalemia. So if you've got a Vega pattern on ECG, please be sure in your history to include whether or not the patient has a recent febrile illness, whether or not the patient may have hyperkalemia. Another example, say the patient has an irregularly irregular rhythm, but you're not thinking atrial fibrillation. You do see what looks like different looking P waves. Could they have MAT multifocal atrial tachycardia? And to keep in mind historically then who gets MAT? And there are two types of clinical syndromes or presentations that are commonly associated with MAT. Most providers are familiar with severe pulmonary disease. The one that I find many providers are not familiar with is an overall sick patient with a multifactorial disease, they're septic hypotensive, maybe even shockey, electrolyte disturbance, acid-based disturbance. And that's part of the clinical history. If I'm considering, could this patient possibly have MAT? Okay, so to emphasize regarding the history with regard to clinical ECG interpretation, please make it short two to three lines at most, but please be thinking of the clinical entities that might be most likely with the electrocardiogram you're looking at and include them in the history. An associated era is not forcing yourself to commit to a diagnosis. So I get lots of tracing some people who say, Hey, I don't know what this ECG shows, tell me what you see. And that's a person who is really not gonna learn if I just tell 'em what I see. So what I routinely do is I say, well, tell me what you think. I send them back the tracing because they've never forced themself to commit to a diagnosis. And anyone who's gone through medical school, but perhaps any other training will know that you've gotta force yourself. You've gotta get a little bit out of your zone of comfort and that's the way that you learn. You force yourself. You commit to a diagnosis, doesn't mean if you're right or wrong. You follow up the case, you learn from your mistakes and you learn when you were correct and you figure out what you can do the next time to make it better. The next broad category of what I call errors is systematic approach. And I think I'll explore this both for cardiac rhythms and for 12 leads, and that'll be the last general topic that I'll be covering today. It's the failure to use the systematic approach. Now all too many providers, even tremendously experienced providers in my experience, they don't use the system. And I can talk for an hour on this, but I'll just hone in on several key facets of this. First of all, using a system does not slow you down. I had so many people saying, I don't want to use the system. It slows me down. On the contrary, it speeds you up because you have a streamlined system, you don't have to worry about doing things and you will no longer repeat because people without systems, they look at one thing, they look at something else, they forget what they looked at before and they keep going back and forth. The

checklist, the systematic approach prevents you from missing anything because you've got a checklist and you sound intelligent while you're going through your differential diagnosis. And even if you don't know exactly what the electrocardiogram or the cardiac rhythm shows, you will narrow down your possibilities. You'll narrow down your differential diagnosis. So the key is the system. And even after interpreting a million or so tracings over my academic lifetime, I still miss things if I'm not systematic. So let me start with the rhythm. There are six things to look at when you're looking at a cardiac rhythm. The first of which is imagine here's your electrocardiogram that you're given on the other side, here's your patient in clinical practice, clinical real life. What do you look at? First you look at the patient, right? Doesn't matter what the cardiogram shows. If your cardiogram shows something like a fast rhythm, doesn't matter if it's V-tach or super ventricular, if your patient is crashing because of the fast rhythm, you've got a cardiovert regardless of what the electrocardiogram is showing you. So the first parameter of the six things to look at is, is the patient hemodynamically stable? Now, if they are, the next thing to do is to think of the other five parameters. And I've developed what I call a memory aid. It's called watch your P's and Q's and three R's. And again, this is something that even after a million tracings I find myself doing, I look for P waves if not present. I look for atrial activity, I look to see if the QRS is wide or narrow, and then I look for the three Rs, which are the rate of the rhythm, both the atrial and ventricular rhythm, the regularity. And if P waves are present, are they related to the QRS complex? So those are the P's and Q's and the three R's. And it doesn't matter in which sequence you look at these and I often change the sequence depending upon what's easiest to look at. But you always wanna ask yourself about each of these particular parameters. And once again, this does not slow you down. I do this in real time. I'll tell you, if you are working with providers, maybe for a code, maybe with a junior resident, maybe presenting to someone senior to you, you really sound like you know what you're talking about. And you may in real life be actually stalling until you come up with a differential diagnosis. But it helps to go over P's, Q's, three R's. I'll emphasize as I give this podcast that a picture's worth a thousand words, it's a whole lot easier to talk about ECGs if they are in front of you, but hopefully I can still convey as I go through the systems here. A couple of helpful hints. So I get lots of tracings that are sent to me and the providers saying, I think this is VT or I think this is SVT. And the error in my opinion is what I call premature closure because there are actually three answers that you have. If you have a regular wide tachycardia, it's either definitely VT and on occasion I definitely know that a rhythm is VT or it's definitely super ventricular or it's neither of those. It's a probability statement. And I can't tell you how many providers feel constrained to have to say it's one or the other. And all of the time I say, well, I'm not a hundred percent sure, I like to give a probability statement. I'm about 90% sure. I like to get as close to a hundred percent as possible. I'm gonna begin to assess and treat the patient as if it was VT. But there's still a little bit of doubt and I'm gonna work through other things until I can get as close as possible to that a hundred percent. So the best answer is not to say it's VT or it's SVT, it's a probability statement. And the best answer is to describe what you see by the P's Q's three R's. This is a regular Y complex tachycardia. The rate is 150, 170, whatever it is. I do not see sinus P waves or I do not see regular atrial activity. Now the next error with regard to this is not appreciating statistical odds. So I see so many clinicians when they're not sure what a regular WCT rhythm happens to be. Now WCT, I like that term wide complex tachycardia, they don't know what the differential diagnosis is, they forget the statistical likelihood. So there are 10 things to consider when you have a regular WCT. Number one, V tach ventricular tachycardia, number two, VT numbers 3, 4, 5, 6, 7, and eight VT. Now number nine is the QRS could be wide because of aberrancy. That's actually an error in itself. A lot of people just think if it's super ventricular and it's wide, it's gotta be a barren conduction. Well, a barren conduction simply

means that because of the fast rate, the QRS, the heart doesn't have enough time to recover. So there's a rate related, a barren conduction, but you can have preexisting bundle branch block, which is why getting an old tracing can help you. So 10 things. A wide complex tachycardia can be the first eight of which RVT number nine is super ventricular with either preexisting bundle branch block or barren conduction. Number 10 is something else. Hyperkalemia very common these days. A WPW related rhythm, some other toxicity. Now the reason 'cause people often ask why are you saying eight times VT? The literature actually shows this. If you have an unselected adult population and you're looking at regular wide tachycardias without clear sign of sinus P waves, statistically at least eight outta 10 are VT even before. Before you look at the ECG. And if your patient is older, and I don't define age, I live in Florida, I went to medical school half a century ago, but older, not 20 or 30, but 50, 60, 70, 50 as young, 60 as young, older with underlying heart disease, you're up to 90% of regular WTS or VT before you look at the ECG itself. Okay, super ventricular tachycardia say you have a regular narrow, complex tachycardia, same approach. Okay, is the patient stable? Usually the, usually they are stable. If the QS complex is narrow, P's, Q's, three R's look for signs of atrial activity. That could be retrograde AC atrial activity that could be saw tooth flutter waves. What is the rate? And a couple of points with this point. Number one is to forget the differential diagnosis. I think of four main things. Now there are others, but almost all of them that we as non EP cardiologists see are sinus tachycardia, A reentry SVT rhythm, that's either AV NRT or AVRT, atrial tachycardia or atrial flutter. So among the common mistakes in rhythm interpretation, number one and number two and number three is not appreciating that the most commonly overlooked SPR ventricular tachycardia is atrial flutter. So typically with untreated that's not on a rate slowing antiarrhythmic medication untreated atrial flutter, usually the ventricular rate is close to 1 50, 1 40, 1 60 or so. And usually you'll see two to one AV conduction. So the point is not to miss atrial flutter, which is the most commonly overlooked rhythm. Whenever I have a regular SVT in the rate is close to one 50 and I'm not seeing clear sinus P waves. I think atrial flutter until proven otherwise among the list, the rate of the SVT can be very, very helpful. So if the rate is not, if the rate is one 50, it could be any of those four entities. If the rate is 180 or one 90, it's not gonna be atrial flutter because that's too fast for two to one flutter. It's too slow for one to one flutter sinus tachycardia. In a horizontal patient you're seeing either at the bedside, emergency department, sinus tachycardia rarely goes much over one 70 per minute or so. So if you have an SVT at a rate of about one 90, that's probably too fast to be sinus tachycardia. And along the relative probabilities we see atrial tach, but it's much less common than a reentry tachycardia such as AV NRT. Let me finish if I can with a couple of points about my 12 lead ECG system. So for 12 lead ECGs, what's my systematic approach? There are six parameters. The first two of which we've already done, what is the rate of the rhythm? Then there's intervals, there are three intervals, which are the PR interval, QRS duration, the QTC, what is the axis? Is there chamber enlargement of any of the four chambers? The two atria, two ventricles. And then I'm looking for QRST changes, which is my memory aid, looking for changes of ischemia. Infarction are there Q waves are wave progression in the chest leads and to look at ST segments and T waves in each of the 12 leads for possible changes of ischemia. And the last couple of points I would make before our time runs out regards the fact of if we are looking at these six parameters, regardless of whether you use my system or you use some other system that you were taught, you've got to look at QRS duration. You've gotta look at intervals early in the process. So again, the three intervals, the PR interval, the Q QRSs duration, the QTC, you've gotta look at it early. Now why do I say that? Well, if it turns out that your QS is wide, then stop the system. This is the only time I go out of sequence. You've got a bundle branch block, and then all of your criteria are gonna change for how to assess the frontal plane axis, how to assess whether or not there's chamber

enlargement, and especially how to assess for ST segment and T-wave changes of acute ischemia or infarction. And the last example, I'll give you regards to another of the intervals, the QTC. You see a patient who has chest pain maybe presents with some heart failure. You see lots of ST segment and T-wave changes. And if you skip the system because you jump to the immediate finding and you don't realize that the QTC is very prolonged, then you're not gonna be thinking of the possibility that you may have a tacho subo cardiomyopathy, which is often highlighted by the fact that you've got marked QTC prolongation in association with ST and T wave abnormalities.

Dr. Kashou - Dr. Grauer. Wow, that's all I have to say. You just, I feel put on an ECG clinic and what an introduction to what's to come. We discuss some of the common errors in ECG interpretation that occur even amongst the most experienced clinicians, whether it's going too fast, not having a system in place, but many of these errors can be avoided and or corrected with a few simple steps. And some of those important lessons, if just to recap, some of them pay close attention to the specific aspects of the history that are often ignored. Dr. Grauer mentioned some of the key components that he likes to hear. You know, keep it two to three lines. Give us the age, give us the patient's sex and just relevant stuff related to the ECG interpreting arrhythmias, a systematic approach, how do you approach the arrhythmia? And then how do you approach the 12 lead ECG? And as he mentioned, we can go on for an hour with that approach. But you heard something here, re-listen to that again and try to write some of 'em down or follow his blog, certainly good material there as well. And then lastly, correlating the relevant history that you captured with the tracing in front of you. And then looking at prior ECGs to see if there's changes. And there's so much more. I believe that the application of these principles, many of the things you heard today, and again, listen to this again, will help you save time and improve the accuracy of your interpretations. Dr. Grauer, thank you so much for taking time to join us. We're so grateful for your support, your countless con contributions to the field and learners over the last, you know, as you mentioned, almost half a century, and we're so lucky to have you to continue to teach us. We look forward to having you back as we move on to acute coronary occlusion. Thank you again.

Dr. Grauer - Thanks Anthony. My pleasure.

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