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. Anthony Kashou: Welcome to Mayo Clinic's ECG segment making waves. In this episode, we explore the world of computerized ECG interpretation, including its optimal use, its impact on clinical practice, and the evolving role of artificial intelligence ai in this space, we're fortunate to have Dr. Ken Grauer back with us today, who is Professor Emeritus in Family Medicine following his residency training and 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 reco retiring in 2010. Dr. Grauer has written over 10 books on ECG and arrhythmia interpretation, presented hundreds of talks and workshops locally and nationally on ECG interpretation and other cardiology topics, and has been an active, as ever since retiring. He has his own ECG blog that he continues to update weekly, almost daily. He is the associate editor and one of them at and contributor at Dr. Smith's ECG blog, and he continues to answer daily questions on many international forums. Dr. Grauer, thank you so much for joining us again today.

Dr. Ken Grauer: Thanks, Anthony. It's great to be here. I appreciate the invitation to talk about computerized ECG interpretations, including especially how AI might benefit ECG interpretations now in the future.

Dr. Anthony Kashou: Yeah,

Dr. Ken Grauer: 2024.

Dr. Anthony Kashou: We might as well just get right into it. I mean, where do you see the role of the computer, which has been with us, you know, since the mid 19th century and has really evolved, you know, initially to kind of improve efficiency, improve interpretation, the clinical workflow. Now we have this expanding world of AI and deep learning models. Where do you see these, these worlds today?

Dr. Ken Grauer: Well, first I'll start with my disclaimer. So what follows are my observations? They represent my opinion. I realize that others may disagree and that's fine. My goal is really just to stimulate dialogue. So application of ai, artificial intelligence, is creeping into our lives everywhere. To me at the same time. This is tremendously exciting, yet still a scary topic in many of the areas in which AI is being used. So the potential for AI to emphasize it's really great and it is limitless, but so is its potential for misuse, regarding potential for misuse of ai. We need look no further than deep fake, which as you know is the AI based technique. It synthesizes media, it superimposes human features, actions the voice of a person with the end result of a very realistic looking likeness or impersonation of people. And for

example, in politics, you can make your opponent say whatever you want him or her to say, potential for problems with this bottom line is we're all seeing this increasing influence of AI on our daily lives. And I, I'll just offer a personal perspective with this. I really think that there's lots of good that can come from ai, and I'll give the example of one area of my passions, which is studying foreign languages. But AI translations in almost any of the major languages now occur nearly instantaneously. And this can occur either from the written word or from scanned text. So you can take a scanned text, feed it into simple Google translate, and almost in seconds you get a translation and you can play the sound. And having followed this for a number of years, the accents of these people that are speaking in foreign languages, they've become better and better. This reminds me of Star Trek, new generation that I used to watch all of the episodes for. And then you have the Starship Enterprise that's out in alien worlds and all of a sudden it's a different alien language and you have a computer, this is how many years ago, instantly translating. Well, that's what AI can do. That's the good, and I'll offer one counterpoint with this from my personal experience in terms of the less good. I recently was involved in an ECG educational platform that regularly employs bots to generate via use of ai, a person's presentations, as well as their goals and their objectives and the bot generated goals and objectives and summary of what I said sounds good. However, because my material is really technical, it turned out to be very, very much off. It was to me embarrassing and inaccurate. So I think that type of bots example can be really very good for something general. But I think there, there's potential for problems. So what is all of this got to do with ECG interpretation? And the bottom line is my strong opinion that while the potential benefit of AI to assist in certain aspects of ECG interpretation is huge, I don't think, and this is my opinion, I don't think we are ever going to eliminate the need for at least some human oversight just as there remains the need for at least some human oversight for almost anything accomplished by computer. Having said that, the amount of human oversight needed is going to continue to decrease as AI programs for ECG interpretation continue to be trained with larger and larger databases. But I think there's always gonna be a need for some human oversight. That's the first bottom line. The second bottom line is that the combination, in my opinion of AI for computer-based ECG interpretations together with the interpretation of a capable ECG interpreter is gonna be better than either alone. So one plus one equals five, having a good computer program and having a good human interpreter. The third bottom line that I see from this, from what I've observed from reviewing countless tracings interpreted by medical providers of all levels of experience, including cardiologists, that a number of fundamental errors continue to be made. You and I talked about this in my last podcast on ECG errors. From my perspective, recognition of these oversights and these errors can be taught and AI guided interpretation I think can help to teach a lot of those clinicians who are open to this feedback. So where are we going then with respect to AI generated computer interpretations and to, to answer this question, I think it helps to take a look at where we've come from in the field to emphasize, as you alluded to in your introduction, the use of computerized ECG interpretations is not new. It's been used for decades. And my involvement with computerized ECG interpretations began way back in the 1980s when as full-time faculty in our family medicine residency program, I was charged with overseeing the interpretation of all ECGs done or performed by our 35 medical providers. We had 25 residents, about 10 faculty. I did this for 30 years. Now, I did this for all of the ECGs recorded in our outpatient center. I also attended several months each year. So I also had experience overseeing interpretations both in the hospital and the emergency department. And what I observed was an increasing tendency over the years to depend on what did the computer say. If the computer said there was an acute mi, then that is what the provider believed. If the computer did not see an MI but said quote, normal tracing, then that was what the provider tended to

believe. And this was not only a local phenomenon, but in my faculty role over 30 years in family medicine, I was a national educator who got to travel around the country. And I was seeing this was really a trend occurring across the country with all sorts of providers, believe what the computer said, 'cause the computer doesn't make mistakes. So medical providers, more and more were looking first to what the computer said and believing without questioning what the computer said, that was the key mistake. What I did not see was any guidance provided by any studies done on computerized interpretations on how best to use the computer. And I think part of this was because the only people doing the studies that I saw were cardiologists together with computer experts. I didn't see any primary care clinicians involved in any of the studies. So question that I raised was whether or not the needs of a novice ECG interpreter of a nurse, of a paramedic, of a emergency physician, cardiologist, whether they're the same or whether they would differ depending upon the training and experience of the interpreter. Now, how best to use the computer for ECG interpretations should be obvious. I mean, what would you expect the computer to be really good at? And the answer is measurements intervals, pr, interval, QRS interval duration of the QTC axis. The computer can be really good as long as it correctly determines where the limits of the particular intervals are, that it doesn't misinterpret what might be artifact. Now we can ask what might be, or what might we expect to be more difficult for the computer to be good at? And the answer is incorporating the history, incorporating serial tracings incorporating, for example, for a patient with chest pain, whether they were or were not having chest pain at the time, each of the serial ECGs were obtained. And with complex cardiac arrhythmias, it's true that the computer can pick up with high accuracy and irregular irregularity of atrial fibrillation. But my thought is how are you ever gonna, all of the potential complexities of all of the unusual AV blocks into computer interpretations. And that's my bias that as good as AI can become for judging whether or not someone has an acute coronary occlusion, I don't think it's ever gonna replace a skilled interpreter for complex, not for simple, but for complex arrhythmias. Now, to make a long story short, I began to study this in the mid 1980s, and perhaps I was only primary care clinician to formally study, at least perform a small study on computerized ECG interpretations. My motivation for doing this study was simple. I hated computer interpretations. I hated the fact that my residents and my faculty would look at the computer interpretation and accept that point blank without questioning things. So I saw a wide misuse of computerized interpretations and I wanted to do something objective as well as having a publish or perish. But I wanted to do something objective in terms of a study looking at this, surprisingly, after I completed my simple study of computer interpretations with some nationally known experts compared to some skilled primary care clinician interpretations, comparing them with the computer, after doing that, I learned to love computer interpretations. So I started by hating them and I love them. Why? Well, I finally understood how best to use the computer, just like the optimal use of the computer for anything you might use a computer for. Same thing with AI guided ECG interpretations depends on your purpose, depends on your goals. Now, as an expert interpreter, what I found was use of the computer, and I'm talking about these older programs, up until the last couple of years, they tremendously increased my speed of interpretation. For example, if I had a normal tracing, it would take me literally two to three seconds, no more to take a quick overview of the computer, see that the computer said normal, recheck that myself, check mark, scribble my initials, I'm done. And the computer very neatly would write out normal tracing and all of the axis and measurements much more accurately and quickly than I can calculate them. Tripled my speed. But I knew that if there were certain abnormalities, I got to learn what the computer was or was not good depending on the program you're using. And of the need that I would have to interpret the tracing myself. So what I also found from my little study was that the benefits of

computerized ECG interpretation depend on the expertise of the interpreter. Now, as an expert, and I call myself an expert because I've literally spent my academic career and the past 40 plus years of my life studying, writing about this and teaching ECG interpretation. So I call myself an expert as an expert, the computer saves me time for non-experts. And I include 90, 95% of virtually all clinicians reading ECGs as non-experts. Now, many of these folks are good interpreters, but they're not experts in terms of having seen all types of tracings and arrhythmias under all sorts of circumstances. And having had the follow up in the feedback to know which patients had an mi, which ones didn't. So those I call them on non-experts, even though many of them may be pretty good interpreters. So to emphasize that those folks that I call non-experts, I think they still can benefit from the extra opinion that a current AI computer program can provide. So I've been talking about then what about now, what can AI offer us in 2024 has advantages for AI guided ECG interpretation? And I'll make a number of points about this. So previous ECG computer programs are of limited benefit in my opinion in 2024 especially, especially in with regard to emergency care, previous ECG computer programs, which is virtually everything except the program I'm about to talk about. And you had Dr. Robert Herman come on your podcast, I don't know if it was about a year ago, but he talked about this particular program. But in terms of prior programs, they're of limited benefit for emergency care. They still can provide us some feedback objectively in terms of measurements. They can give us some second opinion in terms of the presence or absence of chamber enlargement and conduction defects. But I don't think that they are any longer really helpful in emergency care in 2024 because number one, they still miss way too many arrhythmias in my opinion, to be relied upon. And number two is that they are just not good at diagnosing acute coronary occlusion. Now, as to terminology from this point forth, I'm gonna refer to acute coronary occlusion as an omi, OMI, occlusion based or occlusion myocardial infarction. So when I say omi, I'm referring to cath proven total blockage of a coronary vessel. Let's think about it. What matters in emergency care for this patient who presents with chest pain and what matters for a patient presenting with new chest pain or other new symptoms that might be due, do, do and MI is whether or not the patient has an OMI or not. Because if a patient with new symptoms has an omi, then we know that they can benefit from prompt cardiac catheterization and reperfusion with PCI or in those centers that don't have access to 24 7 365 capping with thrombolytic agents. And the good news is that there is a gold standard for determining if a patient with new chest pain does or does not have acute coronary occlusion. And this is different than older programs. I mean older programs when they looked at LVH, what's the gold standard for LVH when there are more than 50 criteria in the literature? And nobody agrees on this and the computer is nowhere near as good as an echo. But there is a gold standard for for OMI for acute coronary occlusion. And that's you've got cath cardiac catheterization validated occlusion. Or if it's not total occlusion, at the time the cath was done at least enough of a finding on cath to say yes, that was a culprit vessel that was occluded just a couple of hours ago. And this has been studied, and as I emphasized in my prior podcast with you on ECG 12, lead ECG errors, if you are stuck on STEMI criteria, millimeter based criteria for whether the patients having a STEMI in terms of which patients should be catheterized promptly, you're gonna miss at least, at least 30% of all acute OMIs. So we talked about this last time just by brief review, what are some of the other criteria well hyperacute T waves? And there is some subjectivity, as I brought up with the LAD pod last podcast, but we're looking for hyperacute T waves. The more leads that show this, the more likely it is to be true reciprocal ST segment depression. Whether there's maximal ST segment depression in either the V two V three or V four and or V four, which indicates a posterior omi. Whether there is that magical reciprocal relation between ST elevation in the inferior leads and reciprocal depression in a VL and whether there st segment and T wave changes. So there was a certain

amount of ST deviation elevation in depression, and as the patient's symptoms change, the amount of ECG changes changed also. That's a dynamic change and you can program AI to detect these changes. And this is what Dr. Herman was talking to you about in that last podcast that you had with him. And the points I will make is that Dr. Steven Smith and Pendell Meyers are doing this. They've been working together with Dr. Herman and Dr. Herman's team primarily. Doctors Smith and Meyers have been working by programming AI with literally data sets of thousands of tracings with cath validated backup as to whether or not there was or was not. An acute OMI and then making corrections based on what they found. If the computer program doesn't pick something up, then it looks at why and it reprograms that. And that's what they've been doing. And there are now validation studies showing that use of the program that they've used is far more accurate than use of STEMI criteria that misses at least 30% of all acute omi. So this is now the future as I see it with ECG interpretation and the future is now. And this AI program is going to continue to get better because the first version of their program is out. There're gonna be additional versions. And I would emphasize at this point that there's still all too many clinicians, including all too many cardiologists worldwide who are stuck on the STEMI paradigm waiting until you get millimeter based criteria for STEMI before they take someone to the cath lab. So they miss at least 30% of patients with omi. But even if they get an omi, they're able to diagnose that oftentimes they're delays. You may not have the ST elevation immediately when the patient presents. So to emphasize the AI program and the name of this that you might hear being used Queen of hearts, is the particular AI program being used QOH. It has learned how to recognize acute OMI from being fed data from thousands of tracings in a data set with cath proven validation as overseen by doctors Smith and Meyers who have that cath validated data. Now, having said all of that, I think there still needs to be clinician oversight to ensure technical issues are not missed. That there's no artifact that you have QOH as good as it is. And it's surprising how accurate it really is. It does not yet integrate the clinical history. It does not yet compare tracings Future versions will be doing this, but it's not here yet. Now, I'll also indicate before I get to my final thoughts on this, that as an expert, I find myself depending less on the queen of hearts. So I still look at the ECG by myself. I make my own interpretations. I'm comfortable with that. Now, having said that, even though I don't really use the queen of hearts to tell me what the co what's going on, I find myself comforted if the AI application interpretation is the same of what I said. So my strong belief, and this is really for anybody, I think any provider ought to cover up what the Queen of Heart says and make your own interpretation first. And I say this for several reasons. Number one, you learn better that way. You force yourself to commit to something and then you get a second opinion. And again, I don't need Queen of hearts to tell me if it's an OMI or not, but it's nice if the Queen of Hearts interpretation is the same as mine. And if it's different than mine, then it forces me to go back and perhaps I miss something. I'm not perfect, I still miss things also. So I think the AI application can be very helpful in a variety of ways. For the less expert interpreter, I'd still say make your own interpretation and then look at Queen of hearts. And it can help to convey a second opinion. And because it's been programmed with thousands of ECGs with cath validated data, it gives you a valid second opinion that you can learn from to get an optimal opinion. Remember a capable ECG interpreter plus the AI interpretation, I think is better than either alone. Future versions of AI are gonna continue to improve. I think even for cardiologists who are still stuck on the STEMI protocol, they can instantly learn from looking at what AI guided protocols show. And I think the future is bright for this combined use of AI guided programs together with an improved knowledge base and experience of capable clinicians.

Dr. Anthony Kashou: Wow, a lot that we just covered there and incredible how much that you said. I mean, even starting, how do you use the computer? You know, you said we've had this for years, your, you know, beginning journey began because you saw people were using it and relying on it and you know, so you had almost an animosity towards it, but then grew a a a, a realization that it adds value in some ways and then finding how to use it. And I think, like you said, the level experience, your skill as an interpreter should really dictate how you use it. I couldn't agree more. In this episode, we explore the exciting and evolving world of computerized ECG interpretation, examining its optimal use based on interpreter scale and experience level, its impact on clinical practice in that every evolving role of AI in shaping the future of this field. Dr. Grauer we're so grateful to have you back for your support, your countless contributions to learners myself over the years. Thank you for taking the time to join us again.

Dr. Ken Grauer: My pleasure. Thank you.

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