Advances in Occlusion Myocardial Infarction Detection

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. In this episode, we'll be diving into the world of artificial intelligence and its role in detecting one of the most critical cardiac conditions, acute occlusion myocardial infarction, or OMI. We're excited to have Dr. Pendell Meyers as our guest, who has been at the forefront of developing an AI system to interpret ECGs and detect OMI. First, we'll discuss the importance of identifying OMI early on and its impact on patient outcomes. Dr. Meyers will then share the details of how they develop the AI system to analyze ECGs for signs of OMI. We'll also explore the testing that has been done to evaluate the model's accuracy and compare it to traditional STEMI criteria and human experts. We'll also discuss the future of OMI diagnosis and how this potential paradigm shift can improve patient care. So get ready for an exciting episode. But before we get started let's introduce you to our guest. Dr. Pendell Meyers received his medical degree from Duke University in 2016 and completed emergency medicine residency training at Stony Brook University Hospital in 2019. He has been co-editor of Dr. Smith's ECG blog since 2018 and is now emergency medicine faculty at Carolina's Medical Center in Charlotte, North Carolina with a primary research focus on improving the identification and treatment of occlusion MI. Dr. Meyers, thank you so much for joining us today.

Dr. Meyers: Thank you for having me.

Dr. Kashou: You know, so finally here with the expert, you know there's only a couple of you out there right now, but it you know, really paving the way, but because this is, I know to you not new, but maybe to some of our listeners, I think maybe could you start with reminding our listeners and our audience that may have not heard of this, or only you know, once in a while, what is occlusion MI or OMI and why is it such a critical cardiac condition?

Dr. Meyers: Yeah, absolutely. So, occlusion myocardial infarction, or what I call OMI, we define conceptually as acute coronary occlusion or near occlusion with insufficient collateral circulation that then results in imminent transmural myocardial infarction, you know, without reperfusion therapy. This is the thing that STEMI criteria is supposed to be identifying, but doesn't identify very well. Unfortunately, we know from STEMI registries that up to 35% of our cath lab activations are false positives without a culprit lesion, and in many cases not even having MI at all, which is number one, dangerous for the patient and number two, a huge waste of resources, of time and resources for the cath lab team. And on the other hand, we know that about 25 or 30% at least of our type one in STEMIs have complete coronary occlusion found on their delayed cath. And we know that that subgroup in STEMIs with OMI suffers almost double short and long-term mortality compared to the in STEMIs who don't have coronary occlusion. So, like many people, we believe time is muscle in myocardial infarction. And so when you have acute coronary occlusion causing MI, we believe identifying those patients as rapidly as possible and

providing emergent reperfusion therapy will improve their clinical outcome. So that's what OMI is. And now, big picture, we intend OMI to conceptually replace STEMI and be the next version of the paradigm for acute myocardial infarction. You know, we had Q wave MI and STEMI. These are paradigms that classify this entire disease, based on one inconsistent finding on a surrogate test for the disease instead of the actual pathology or the mechanism of benefit that we're providing. For example, we don't define, like all of stroke, based on some surrogate finding of stroke on the initial exam. We don't define stroke based on like, a high NIH stroke scale score. Instead, we have the large vessel occlusion paradigm left stroke, in which the paradigm has been refocused on the actual pathology and the actual mechanism of benefit that we're trying to achieve. So we've had the Q wave and non Q wave MI, you know, until the year 2000, and we've had STEMI since 2000. And we believe the next version of this paradigm will logically be refocused on the identification and the reperfusion of OMI, maximizing that benefit that we can give to those patients with acute coronary occlusions.

Dr. Kashou: Very fascinating. And so just to recap some of what you said is that, you know, we have this pathology, this occluded vessel, you know, maybe think of as a heart attack or a form of, you know, one form of it, but this form of a heart attack has occluded or near occluded vessel that has ramifications and, you know can impact patient care. And there's a number of them go that go missed. And maybe it's not because that they should be missed but maybe the criteria we're using to identify some of this pathology is maybe not perfect. You know, while some of them are captured, there's also others that are missed. And it's clear that we know that if we treat some of these earlier, the the outcomes are better. Now, Dr. Meyers, this whole AI world and we're kind of quickly evolving into it, and you know, I feel like there's always a new paper coming to my email every day on the next algorithm, but this one's quite fascinating because it really does impact care. You know, there's some of them that affect maybe a lower prevalent population, that maybe the impact is not as urgent but in this case, we know that, say a STEMI, it impacts the emergent care of our patients, and so I'm really excited to learn more about this AI system and maybe you could share, you know, the creation process of it to interpret and diagnose OMI and you know, where the testing has done and how it compares to, you know the STEMI criteria and experts. So the floor is yours. Please, please share.

Dr. Meyers: Absolutely, I'll start by explaining the rationale behind why we thought this could be created with AI based on mimicking human expertise, and then I'll kind of tell you more about what's been happening as we have started to create it. So I'm gonna refer to what I call the, like a chain of logic, or I'm gonna tell you the links of logic that led us to believe that this could be done. So the number one link in this chain of logic is what we've just said, which is STEMI negative OMI patients are frequently missed and have inappropriate delays and this is associated with worse outcomes. So we think that those patients should be found. That's number one. Number two is that we have proven that humans specially trained to identify OMI on and OMI mimics on EECG can reach much higher levels of accuracy than STEMI criteria and then current practice. I'm happy to talk a little bit about that if you want. For example, Steve Smith who you've had on the show, my mentor and I have published our blinded accuracy on our database of ACS patients. This is a database of over 800 ACS patients. 265 of them have OMI, and we have published our accuracy at saying that EKG means acute coronary occlusion and that one doesn't versus STEMI criteria. We showed that we had about the same high specificity as STEMI criteria in the low '90s with more than double the sensitivity. So STEMI criteria in that

study had a sensitivity of 41% for acute coronary occlusion and Steve and I blinded, had expert sensitivity of 86%. So the point here is that using these findings, using better EKG interpretation, humans can greatly improve sensitivity for OMI and maintain high specificity. So with with seeing the success of that, of those ECG findings for detecting OMI what is the next link, the next link in the chain of logic? We need to find them. We can find them. So what is the missing link that is the next way forward in that chain of logic? The problem is this whole time, the one best criticism of our idea has been the following. Okay, this is fantastic, you can see OMI on the EKG better than STEMI criteria. But if it takes so many years of practice and special interest to do this, then how do you expect everyone around the world to do this? Do you expect everyone to stop what they're doing, stop what they're researching and practice EKGs for years? Do you expect to train humans like a radiologist, who will function in real-time for a hospital system and read the EKGs? How will you bring all of this to bedside anywhere, anytime? And so for years, we have known that the answer to this would be AI or neural networks or whatever the smart people are calling it these days. We put out this call to the world years ago. We've been meeting with AI companies since like 2015 or maybe even earlier, trying to convince them to develop AI for OMI detection for the 12 lead ECG for this exact purpose. And finally, finally, we got in touch with Robert Herman of Powerful Medical. This is an AI startup company in Slovakia, who you've had Dr. Herman on the show just recently, and together we've been working on AI for OMI detection on the EKG since only last year, since 2022. And this is a good place for me to disclose my, you know, bias and conflicts of interest here. I'm a consultant to this company. I was hired with the singular purpose of helping to train and develop AI for OMI detection. So please, take everything I say about the company and the results I'm about to share, all that with the grain of salt. So now, if it's okay with you, Anthony, I'll go into, you know, how we created this AI system and then what it's like, is that okay?

Dr. Kashou: Yeah, yep and, and you know, obviously whether you're a consultant or not, if you're doing honest, good work, it should reflect that in so me knowing you, I only expect that. But yes, please go on into tell me about this process and you know, what's been done and yeah.

Dr. Meyers: Absolutely. So we have created an AI program that interprets a resting 12 lead ECG with the intention of saying whether there is acute coronary occlusion or not, as an underlying diagnosis for that patient. We have affectionately named this AI program the Queen of Hearts. So I'm gonna refer to her as she. She is a computer program that can be fed any image of a 12 lead ECG in any format, any lead format, whether it's the actual digital ECG data from the machine, or just a crappy phone screenshot of the printed ECG paper at bedside using any smartphone, and she then gives a prediction of whether that patient has OMI or not OMI, along with the level of confidence. So in my very simple mind, I'm not a data scientist or anything, I can't create this AI myself, but in my mind, what she's doing is she's comparing the ECG you give her against the training data that we taught her and the training data currently includes about 18,000 ECGs with about 23% of those ECGs being from OMI patients patients, who actually have acute coronary occlusion. For each of those 18,000 ECGs, Steve and I labeled those ECGs as either OMI or not OMI. Then the company's computer science engineers took that data and created an AI that optimally differentiates those two groups, based on nothing else but the EKG waveform. Doesn't have any clinical data. I mean not even age, it's just the ECG and that's what we call the Queen of Hearts. Currently, she just says OMI yes or no but with a confidence level. But this is just her first version. We just just made this end of last year and so obviously, long

term we plan to train her to say where's that OMI? What is the most likely culprit vessel? How acute or subacute is that OMI? Is the artery still closed or is it starting to reperfuse? All those things will be important questions for later training. Right now she says, OMI, yes or no.

Dr. Kashou: Just, and so that's where the testing has gone or is there more testing? And have you compared this to traditional STEMI criteria yet?

Dr. Meyers: Yes, we have, so that what I described was developing version one, I guess I'll call it, of the Queen of Hearts. Next, we did a multi-center retrospective validation study. We've just now submitted this for peer review, so not available yet for everybody, but hopefully soon. So in our val-- And I'm gonna describe some of the results from that in that main descriptor. So in our validation study, we used two US centers and one center in Belgium, and we collected a total of 2,263 patients. 20% of the patients had the final outcome of OMI. We then asked the Queen of Hearts, OMI or not OMI, for all those 2,263 patients and she said, yes or no. Steve and I also reviewed the ECGs blindly and chose OMI or not OMI, completely blinded to everything. and then we also measured STEMI criteria. We had other physicians measure STEMI criteria for all those ECGs, using the fourth universal definition of MI. So overall, we have three contestants, Queen of Hearts, human OMI ECG experts and STEMI criteria. So we compared each of those to the actual patient outcome definition of OMI. The outcome definition is based on having an acute culprit lesion on angiogram and then there are various cutoffs of TIMI flow and elevated troponin. You can make the definition as strict or as loose as you want it to be. Regardless of how strict you want OMI to be, as the actual outcome definition, whether you want it to be always has to be a TIMI zero culprit, or whether you allow things like a higher TIMI flow score with a very high troponin. We chose a troponin T high sensitivity of 1000 nanograms per liter or greater. No matter how strict you want it to be, even if you just say TIMI zero, the results are all basically the same. The Queen of Hearts and what we're calling OMI ECG experts were about equal and both of them were far superior to the STEMI criteria. So I'll share some of the accuracy statistics with you now. For sensitivity for the outcome of OMI, we have 83% sensitivity for the Queen of Hearts, we have 76% for ECG experts and we have 34% for STEMI criteria. Specificity, 93% for Queen of Hearts, 95% for ECG experts and 97% for STEMI criteria. For an overall accuracy, Queen of hearts and ECG experts are tied 91% overall accuracy and STEMI criteria 85%. So obviously, the Queen of Hearts and ECG experts are far far more sensitive for OMI than STEMI criteria. But you may be wondering what about that slightly like, 2% decreased specificity. Wouldn't that mean more false positive cath lab activations in exchange for that double sensitivity? Well, I'll just tell you the data and then you can see for yourself what's happening here. So there were 131 false positives by Queen of Hearts, meaning either they didn't have a culprit lesion or they had a culprit lesion, but the MI wasn't bad enough in terms of TIMI flow or peak troponin that it qualified for our OMI outcome, which is quite high of an outcome. There were only 44 false positives by STEMI criteria. But if you look what actually happens at, if you actually look at these patient groups, you'll see how how different these two groups are. For the Queen of Hearts's false positives, 54% had acute myocardial infarction. Of the STEMI false positives, only 34% have AMI at all. Of the Queen of Hearts false positives, 31% have AMI with a culprit lesion that required PCI for that patient. Of the STEMI false positives, only 11% had AMI requiring PCI. So although there's a greater number of false positives by our outcome definition for Queen of Hearts, these false positives by STEMI criteria are way more likely to be really, truly false positives, meaning not even having MI, let alone

needing an intervention in the cath lab, whereas the false positives by Queen of Hearts had a 1/3 chance of having an MI needing a stent in their culprit lesion. So in my opinion, a lot of those are not wasted trips to the cath lab, like a STEMI positive EKG with normal coronaries and zero troponin might be a wasted cath lab trip. And if you're still worried about those false positives, remember the Queen of Hearts gives a numerical outcome. This, she can be programmed to whatever specificity you want. So the specificity and sensitivity we put in the paper is her optimal cut point, like the best point on the Sheever operating curve. But we also present in the supplemental appendix, a version of her where she is told that she has to match the specificity of STEMI criteria. So we set, we dial in the specificity 97% and even at that level of specificity, her sensitivity just drops a little, just drops significantly from 93 to 70%, which is still more than double the sensitivity of the STEMI criteria at 34%. So bottom line, I think our data is going to show that Queen of Hearts has far superior accuracy for detecting OMI on ECG than the currently used STEMI criteria, and most importantly, has perfect interrater reliability by any user anywhere in the world.

Dr. Kashou: You know, Dr. Meyers, it is really remarkable. The one thing I do applaud is this is needed. Like, we need better ischemic detection, whether it's OMI or not, just getting people that need treatment earlier is important. And I certainly applaud you and I have a so many questions that we'll probably even discuss after, but I do want and maybe even have you back on to discuss those, but where do you see the next steps? Because I really want you to kind of share. You're on the the front end of this, of the OMI AI, and the overall paradigm of the diagnosis and treatment of it.

Dr. Meyers: Yeah, absolutely. So I'll take it right back to my chain of logic here. So number one, these patients need to be identified. We believe they could do better with better, faster treatment. Number two, humans can find it and so we think AI can find it. Number three, I think we're about to show that AI has now been created that meets or maybe even exceeds our human performance, and most importantly, can be applied by anybody, anywhere with no interator reliability problems. So this unlocks the next link in the chain of logic, which is of course, to prove it all, right. So hopefully our validation study will soon be published so everybody can see all these results and start, you know, mimicking this and validating this. Second, we have many sites lined up to perform more external validation studies. We only had 2,263 patients in our first validation study. So we need to get a broader testing group and really try to poke all the holes we can in this AI program and see what she's doing well and what she needs more training on. For example, I've recently, I quiz her all the time and I try to try to trick her into saying the wrong thing. One of the things that I've found she needs a little help with, needs more training with, is the idea of this arterial pulse tapping artifact. So there's this very interesting artifact that is perfectly locked to the cardiac cycle, and it causes all kinds of mimics of OMI. It looks like elevation, it looks like hyperacute T waves, looks bizarre, and she didn't have enough of those in her training data set. So she frequently calls those false positives. So we're going to test particular mimics or particular subtle patterns and make sure that she can do each of these things. Next, of course, we have to keep doing more and more rounds of training with more and more data. So ideally, after every data set is used for validation and testing and evaluation, then that data needs to be fed back to the AI with the actual patient outcomes. As a result, every subsequent version of Queen of Hearts should have access to more and more high quality data, increasing her performance more and more. Meanwhile, you know, on the company side,

Powerful Medical is applying for FDA approval in the United States soon. So hopefully, that process will be happening soon and maybe most importantly, it's time for an RCT to evaluate the actual patient-centered benefits of the entire OMI paradigm. So now that we have a way to prospectively identify OMI ECG findings for anyone, anywhere, with no interater reliability problems, we can finally do trials that it will take to convince people that there is benefit to using the entire OMI paradigm to finding OMI as early as possible and reperfusing it. So we're currently exploring some possible options for an RCT using Queen of Hearts. The study design would be something like this. If a patient has ACS by history and findings of obvious STEMI positive O on ECG, no change to care, right? That patient's going to get perfusion, just like we all already know. But if a patient doesn't have clear STEMI on ECG then what does the Queen of Hearts say? If she says that that patient has STEMI negative OMI, meaning they have concern for OMI, then that in STEMI patient should be randomized to emergent perfusion versus usual care, which almost always means delayed cath. So then you could compare the outcomes between the STEMI negative OMI group who got emergent cath versus the STEMI negative OMI group who got usual delayed reperfusion delayed care. So I have problems with whether that's ethical or not to delay reperfusion in a patient with OMI but most of the world currently believes that that question has clinical echo poison. Many of the people I speak with say that they would require that level of evidence to change their practice. So I think an RCT like that will be coming soon. And overall, you know all those plans I just discussed, that's the horizon for that I can see for, you know, my research group and this company.

Dr. Kashou: Thank you, Dr. Meyers. I mean, it's incredible. Again, I applaud you for taking on this important work and also really pushing back against the grain and I think we need more of that. So congratulations to you. You know, I know you and the whole team. I'm really impressed and lucky to see all this advancing. The use of artificial intelligence in identifying and detecting occlusion myocardial infarction is a significant advancement in the field of cardiology. We've gained valuable insights from Dr. Meyers today on the development and testing of an AI system for interpreting ECGs and detecting OMI. As we conclude this episode, we look forward to the future of OMI diagnosis and treatment and the impact that this revolutionary paradigm shift can have on patient care. Dr. Meyers, we extend our sincerest appreciation for sharing your expertise and work with us. On behalf of our team, thank you for taking the time to join us.

Dr. Meyers: Thanks so much for having me.

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