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 delve into the intricacies of premature ventricular contractions, PVCs, and their impact on cardiac health. Joining us is a cardiac electrophysiologist whose expertise in PVCs has been important in advancing our understanding of the field. Our discussion will explore the nature of PVCs, their clinical implications, and the pivotal moments in determining when these ectopic beats warrant concern. Furthermore, we'll uncover the potential role of AI, artificial intelligence, as well as the various treatment options available. But first, let me introduce you to our guest, Dr. Guru Kowlgi, an assistant professor of medicine at the Mayo Clinic in Rochester, Minnesota, completed his medical education at Maulana Azad Medical College in Delhi University in India. He then finished his internal medicine training at the University of Connecticut and his cardiology fellowship at Virginia Commonwealth University in Richmond, Virginia. Thereafter, he completed his clinical cardiac electrophysiology fellowship here at Mayo Clinic in Rochester, Minnesota, and then was recruited by no surprise, to stay on staff here at Mayo Clinic. Recently, he successfully completed a Master's of science program in artificial intelligence in healthcare. Dr. Kowlgi has authored well over 75 peer reviewed manuscripts with research interest spanning from cardio neuroablation to the cardiac applications of artificial intelligence. He actively participates in the medical community serving on committees and editorial boards, and has earned several awards for his clinical and academic achievements. You can also find him actively engaging on social media where he has the handle the rhythm doc. Make sure you follow him. Thank you, Dr. Kowlgi for joining us today.

Dr. Guru Kowlgi: Thank you, Dr. Kashou. That was a very kind introduction. Very happy to be here.

Dr. Anthony Kashou: Well, certainly, you know, all your AI efforts, but you know, I want to talk to you about this PVCs. I we've had to kind of wait a bit because there's a lot of work in the background. You, you got through the masters and there's a lot of, I think we're finally at the point that we can learn a lot about what you've been working on. And so before we get into kind of all the, the topic just for our audience, let's begin just like, what are premature ventricular contractions, PVCs, and why are they clinically important to us?

Dr. Guru Kowlgi: Yeah, that's important. So, great question. PVCs are extra beats that happen in the ventricles as the bottom chambers of the heart, and PVCs are the most common arrhythmia that affect the ventricles. You know, when we do these Holter monitors, well over 75% of patients who undergo monitors have PVCs. So they're not uncommon. But the, you know, thing we are faced with every day is what PVC should we be concerned about and, and what PVCs can we just leave alone saying that these are benign? So there are a few factors to consider. You know, because PVCs, if they happen, especially in a, in a frequent number, let's say over 10 to 15% of the beats can lead to what we call PVC

cardiomyopathy. So that leads to weakening of the heart muscle. So in the normal cardiac conduction, the bottom chambers are activated through the AV node and the His bundle, which is located in on the septum, which is the center wall of the heart, and then it branches out to the bundle branches and activate the right and the left ventricles. But you can imagine if a PVC comes from the apex of the right ventricle that's far away from where the normal conduction breaks and that happens, it's essentially like the heart is sort of walking upside down, you know? So if, if we start walking upside down for half the beats, you know, we, we'll have some imbalances and, and some adaptations, which are not good. So that's kinda what happens with the heart. So if you have frequent PVCs that can lead to heart failure and we need to identify the patients at risk when we see patients with PVCs.

Dr. Anthony Kashou: Too much is, is not good. And I, I like what you said, walking upside down. I haven't heard it that way, but that's a, that's a great way to put it. Kind of outside the normal conduction pathway. These beats too many of them are not good. And you know, as a clinical cardiac electrophysiologist, you see this a lot and not, you know, all of us know how to manage this. When do you start getting concerned? You kind of gave that burden or that percent? What is the kind of the threshold where you say, okay, you know, a general physician or advanced practice provider should send them to you?

Dr. Guru Kowlgi: Yeah, so good question. So again, the burden is helpful and what is also helpful is that the patient has symptoms. So sometimes, you know, even, you know, irrespective of the burden, patients can have palpitations, they can feel these PVCs, they can get lightheaded at times because it can affect their blood pressure. You know, on the PVC beats, they can get what we call pre-syncope symptoms, or actually in severe cases even pass out if they have a bunch of PVCs in the run. So when we had these symptoms, then there's a no-brainer that we have to treat them. We have to try and eliminate the PVCs either with medications or with procedures called catheter ablation where we put catheters inside the heart and find the spot where these PVCs are coming from and burn or freeze a small part of the heart muscle in order to, you know, render them non excitable and and eliminate the PVCs. Now if the patients don't have symptoms, that's where the challenge is, you know, so what burden should we be looking at? There's no fixed number. You know, you can have patients with 15% PVCs who develop cardiomyopathy, and sometimes we have patients with 25, 30% PVCs who have normal ejection fraction. And because our medications as well as ablation, they can have negative consequences. You can have side effects of the medications, you can have procedural complications with these ablations. So we have to be very careful in identifying the patients who would benefit from this. So that's kinda where, you know, AI comes into the mix. But then traditionally before AI was there, we had some ways of identifying patients at risk. So if we say the PVCs are coming from the epicardial surface, the outside surface of the heart, we're a little more concerned If we say the PVC burden is more than, like I said, 15, 20%, no, little more concerned if the PVCs are coming too close to the previous beat. So we call that the coupling interval. So on the ECG, one big box is about 200 milliseconds. So if your PVCs come coming within 200 milliseconds of the previous beat, then we are slightly more concerned because that can increase the risk of arrhythmia, sustained arrhythmia in the bottom chamber. So while these are traditional risk factors, we know that there's more to it that we don't understand, and we need to pick these patients who develop heart failure sooner than we currently do.

Dr. Anthony Kashou: Hmm. So it, it's not only, I'm hearing like the, the burden when they're occurring also in the cycle and the symptoms, you know, but you mentioned AI and I want to kind of get to what you're doing, but what tools do we have now to detect and localize them? You know, we have the ECG, how do you do it? What are you looking at for like these high risk PVCs?

Dr. Guru Kowlgi: Yeah, so with AI, you know, we are trying to pick a subclinical version of card, PVC cardiomyopathy. So some of the background work that I have been involved in with PVC cardiomyopathy is looking at animal models to pick up subtle, you know, characteristics on echocardiogram that tell us this patient is developing cardiomyopathy before the ejection fraction drops. So the classic way of detecting heart failure is we put an ultrasound probe and we measure the pumping function of the heart. If it is less than 50%, we call that systolic heart failure cardiomyopathy. Now we know that there are parameters such as echocardiographic strain that can be affected before the ejection fraction drops. So I won't go into too much detail, but then during my fellowship we had a canine model where we implanted pacemakers in dogs and assimilated PVCs in every other beat, followed them for 12 weeks and saw, okay, cardiomyopathy happens and what happens before the ejection fraction drops and identified some strain parameters that that get affected before that. So with that background and knowing that AI can detect subtle changes on the ECG before they become apparent to the human eyes, and before it becomes apparent on echocardiogram, we thought maybe we can apply AI ECG to patients with frequent PVCs to identify those patients at risk of cardiomyopathy before the ECHO even shows it. So that was the genesis of this sort of project. And then we looked at a bunch of patients who had paired ECG and ECHO data, so about 69,000 pairs to be precise. We broke them up into a training group and a test group, and then we trained our deep learning neural network model to look at the ECG at baseline and predict the risk of PVC cardiomyopathy within two weeks. So we have an echo within two weeks of the ECG. So that tells us that what was fascinating is yes, the model performed really well akin to some of our other AI ECG models for heart failure. But what was fascinating was, you know, even those that the PV, the AI model said had abnormal EF at baseline, but they actually had normal EF on echocardiogram. So they were sort of these false positives, so to say. When we followed them over a period of five to 10 years, they developed cardiomyopathy significantly more than those patients that had a negative AI predictor at baseline. So not only is the model detecting concomitant cardiomyopathy, it is detecting future cardiomyopathy. So that I think is the most powerful take home message of this model that let's say we are faced with a patient who is asymptomatic, who has around 10%, 15% burden. We don't know at this point what to do with them. You know, so they're not having symptoms, should we just wait and watch till they get heart failure? And as a patient, if, if I had PVCs, that doesn't sound too reassuring, you know that, okay, we'll wait till your heart fails and then we'll try to fix it, right? So you wanna do it early if you can. So if you can identify a high risk population with this AI ECG, that could be a game changer.

Dr. Anthony Kashou: You can just imagine that if you had such a high negative predictive value in those patients and you could say, Hey, you know, we don't know you're asymptomatic, you have this burden, but look, we have this data that shows that you have your risk is low, you know, we don't see it. It's,

you're right for patients. It's a reassuring, and I think also a clinician having that extra data point really makes a difference.

Dr. Guru Kowlgi: I'm glad you brought that up as a negative predictive value. The actual number is 96%, so it's quite high, you know, so we can be pretty confident about ruling out some of those low risk PVCs. We'll still follow them, but maybe not as closely and not like three monthly echoes or something like that.

Dr. Anthony Kashou: Yeah, no, I, I know you've already mentioned a couple of the treatment modalities, but recap kind of, you know, how do we manage these? We have someone that's symptomatic or high burden. What are kind of the modalities you have at your disposal?

Dr. Guru Kowlgi: Yeah, so you know, what we do is a combination of medical therapy with these antiarrhythmic medications or catheter ablation. So there are a whole slew of medications that can be used to reduce the heart rate. And those are you generally first line agents that can be started by their primary care providers or cardio general cardiology clinics. But when they break through, those medications still have symptoms. And PVCs, they get referred to heart rhythm where we can give them stronger antithetic medications, which block certain channels in the heart. Now these medications have the potential for more side effects, so they need more monitoring. And the efficacy is, you know, I'll say around 60, 70%. And some patients have a significant benefit and others don't. Now, that's where catheter ablation comes in. If the PVCs are arising from a non, you know, critical area, like they're not close to the conduction system, they're not close to the coronary arteries, you know, we are pretty good at ablating them and getting rid of them, I'd say around 80 to 85% success rate. But if they're arising from these critical areas or they're deep within the muscle, then the success rate is a little lower on 70 to 80%. But in general, that's a good treatment option. Like I mentioned earlier, both medications and invasive procedures have the potential for side effects and complications. If you have to be wary of that fact as we select patients for these,

Dr. Anthony Kashou: That's, that's wonderful and thank you so much. I mean, and just seeing how the potential, and we've seen it clinically, how this could, you know sh point us to a different direction, also reassure our patients. In today's episode, we discussed some of the complexities of premature ventricular contraction, PVCs, and their potential impact on cardiac health. Dr. Kowlgi provided invaluable insights into understanding these PVCs, highlighting their clinical importance, that burden, if it's too high, having the risk of PVC, cardiomyopathy, the variety of treatment modalities, and then shared something new with us, this innovative use of AI in detecting and localizing and predicting the high risk PVCs. Dr. Kowlgi, thank you so much for sharing your expertise. I continue to always learn from you your unique perspective in this field, always kind of pushing the limits. Thank you so much for your contributions and I hope you'll join us again.

Dr. Guru Kowlgi: Thank you Dr. Kashou. Always a pleasure.

Dr. Anthony Kashou: Thank you for joining us today. We invite you to share your thoughts and suggestions about the podcast at cveducation.mayo.edu. Be sure to subscribe the Mayo Clinic cardiovascular CME podcast on your favorite platform, and tune in to explore today's most pressing electrocardiography topics with your colleagues at Mayo Clinic.

Announcer: This has been a Mayo Clinic podcast.