Device Agnostic Artificial Intelligence-based Analysis of Ambulatory ECG Recordings

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 an exciting episode planned for you, as we discuss device agnostic, artificial intelligence-based ECG analysis. We have an expert discussing joining us, and he's gonna help us understand this topic better. Within the last decade, there's been a tremendous amount of research on the application of artificial intelligence in medicine. This ubiquitous, inexpensive, and non-invasive test has been an ideal modality for early studies. In this episode, we will learn about device agnostic ECG interpretation, including what it is, how it differs from traditional approaches, and how artificial intelligence ECG interpretation will affect the future of cardiology. We're fortunate to have a recognized expert in the field, Dr. Allen Kennedy, to discuss with us further. Dr. Kennedy is a biomedical engineer by training, and holds a Ph.D. in the application of deep learning for the diagnosis of medical conditions from Ulster University. His research in this field is internationally renowned, and he has received awards from the Institute of Engineering and Technology, as well as the International Society of Computerized Electrocardiology. Dr. Kennedy worked at Phillips Healthcare as a research scientist, specializing in the development of machine learning-based methods for cancer detection. In June, 2020, Dr. Kennedy started PulseAI, which is a startup company focused on improving the detection and management of cardiovascular disease using artificial intelligence. His current work focuses on developing wearable ECG patch technology and deep learning algorithms for ECG classification. Dr. Kennedy, what a true honor to have you with us today. Thank you so much for joining.

Dr. Kennedy: Thanks for having me, Anthony.

Dr. Kashou: You know, I thought we'd just get to it. Is this device agnostic ECG interpretation? I think that agnostic part is almost, kind of a new and new to many of our audience. And so, maybe you could share what is meant by "device agnostic ECG interpretation"?

Dr. Kennedy: Sure, sure, yeah. So what I really mean when I say device agnostic, and we've done some publications in this area as well, is that we use data that is not from the device that we're testing the actual algorithm on. So, we have a large database here, over a million ECGs that we use to train our AI with. And what we want to do with that is take those ECGs from the clinic, whether they be 12-lead ECGs or ultra monitors, or move out cardiac telemetry units or whatever that may be, and train an artificial intelligence at deep convolutional neural network, to be able to do ECG interpretation on a wide variety of signals, so that we can deploy them on a range of different types of devices. So, everything we've been working with is things from, like, a smart ring, to a smart necklace, smart watch some smart clothing, but also right through to, like, your standard 12-lead ECG interpretation devices you would have in most clinics and most hospitals. So when we say device agnostic, we really mean we want to have anything with an

ECG sensor in it. We can take that data and provide an accurate automated interpretation for it, so it can inform patient management and really provide an accurate interpretation of that data. That's what we're really looking and that's what we say when we mean device agnostic ECG.

Dr. Kashou: So device agnostic, essentially like any device, and the whole hardware and that's another world, is growing in itself. And so, having all these wearables and different devices essentially enabling, you know, the use of these technologies on them. I guess how do you consider the relationship of the AI-enabled device agnostic ECG interpretation to more of the traditional ECG interpretation software used today?

Dr. Kennedy: Yeah, yeah. So, a lot of my early work in actually ECG interpretation is focused on what we would call heuristic algorithms. So, we would be working with devices and we would really have to tailor the algorithm to the device that we were working with. So for example, if you were trying to detect, like, p-waves you would have to tailor it to the noise level of the device that you're working with and so forth and have to really calibrate it to a device in that sense. So when we're looking at traditional algorithms they still do that and then sometimes that's why you can get some erroneous interpretations from those traditional ECG interpretation algorithms. But the real advantage of AI is, is what we would use it for, is we could train the ECG interpretation on what the cardiologist has said, what the outcome was, and just let the computer figure out what actually the key features from the signal is that it needs to try and interpret. As opposed to us trying to specifically program it with heuristics to say, well when this loop of this line goes up or down, then we want to do this particular thing with signal processing. We've kind of stopped doing that now and we've really focused on looking at managing large amounts of data and feeding them into what we call convolutional neural networks. So the convolutions can do that automatic feature extraction and replace that heuristic thing that was in traditional monitors, which kinda as sometimes you would see, and you've probably seen it yourself, is when you do look at, like, an atrial fibrillation false positive, it'll be looking like, they'll have PACs on it and it'll have very low actual P-waves. It's just because the heuristics didn't pick up those small P-waves that it would actually flag it up as atrial fibrillation. And that's where those abnormalities don't seem to happen with those tech still, it still does happen, but not to the same amount with these AI-based interpretation algorithms. So, that's really the difference, is that the AI learns directly from the data whilst the old traditional algorithms we would actually have to program them what to do. And that is the big difference that I see in that field.

Dr. Kashou: Now I guess a separate question then, it just kind of came to mind. When you say the device agnostic component and you make these models, can you then apply them to those same different devices or does the signal matter in terms of the fidelity? Yeah.

Dr. Kennedy: Yep. Yeah, so that's we really found something that's very exciting about what we are working with. We integrated things like the Apple Watch and a number of different types of devices, but we only trained it on clinical ECG, but it still is actually passing prospective clinical validation of these types of devices for arrhythmia assessment, and some situational secure restoration measurement and QT monitoring. So what we have been able to do is actually, and there is a little bit of intricacy about how we train the neural network to do this, but we spent a lot of time engineering a neural network that we can have agnostic to the recording device, so that even if we have some noisy recordings from a dry electrode, as opposed to the wet electrode

you see in the clinical environment, it can handle that, and still extract the features that it needs to do an accurate interpretation.

Dr. Kashou: It's really fascinating. I think that's an important thing that, you know, we wonder and I guess as I get to this last question, which we consider almost the golden question, is how you envision, you know, AI, artificial intelligence ECG interpretation affecting the future of cardiology? And maybe you could also, you know, mention, you know, PulseAI, which now it's been almost a few years, two years now. So, just came on that. So, maybe a little bit about that and what you guys are doing and then, the future of the field.

Dr. Kennedy: Yeah, yeah, sure. So, what we do really is we have what we call an API, so a programming interface that people can post data to from any different type of device. And we get either a 12-lead interpretation or single-lead interpretation of that data. But really what I think it'll happen is, and we are constantly thinking about these use cases in the background inside PulseAI to see what the best application of AI is. Because a lot of people get scared that it's gonna try and replace jobs or it's gonna try and replace the personal decision making process. But really what we want to do, is improve the efficiency of people going through very large amounts of data. So for example, I think Apple's sold like 30 million Apple watches last year and each one of those has an ECG sensor inside. So the amount of data coming through from ECG sensors is on a scale that we've never seen before and it's not going to allow people to over read all of that data. And that's where I think AI will really be able to help, is to go through that very large amount of data perhaps help a triaging of the very large amount of data, identifying people that need help straight away or they need to be prioritized. And it will help, I think, clinicians do a more accurate and efficient interpretation of the ECG, as opposed to trying to replace the position in that ECG decision making process. Which I think is a critical use case, that we actually augment the person, as opposed to trying to replace the person with AI. And that's something we're very excited about and we have been integrating a number of different devices with our platform. And we're working on a number of exciting different things in terms of looking at what traditional ECGs have been doing for interpretation. I'm wondering even, so for example, all the 12-lead ECG interpretation labels that you would get out from your typical monitor, are all of those required? Or do they have clinical value to each one of them? And we're going through those, almost one by one, and training our neural network to really have the, what we hope is the greatest amount of clinical value coming out of the interpretation. So, not that it's just like, for example separating atrial fibrillation, atrial flutter may not have a big outcome in terms of the changing of the management of the patient. So we don't work those things as heavily as, for example, picking up an infarct or missing an infarct or something that's a lot more serious on the ECG. And trying to contextualize that clinical information with the partners that we work with. Some people like yourself, they're very well respected people in the space of ECG interpretation. And we use that clinical information to try and free a neural network to do this more effectively. And that is really what we're obsessed with day to day inside of Pulse AI, is trying to get that, bridge that gap between very nicely engineered technology and actually providing clinical value to the patient. And, that's really what we're doing now is we're going through prospective clinical validation, which is a tough process, but we're learning things day by day as we go through that validation of what we need to do better with our technology and what can provide the greatest amount of value. So it's a very exciting time for PulseAI at the moment.

Dr. Kashou: Exciting time for you and we really appreciate the work you're doing and I think you kind of hit on the key points, which is, you know a lot of the AI, we don't see it as replacing but augmenting, right? And it's augmenting our skills as clinicians or as interpreter technicians to not miss things. And there's just a lot more, and the data's growing even larger. You mentioned all the Apple data, and really how do we fine tune and expedite the clinical workflow. And so I'm really excited and, like you said, this is an exciting time for us as a field and we're glad that, you know, you're a part of that leading team doing that.

Dr. Kennedy: Yeah. Thanks for the kind words Anthony. It's always great to get the recognition from yourself and the Mayo Clinic. And you guys really to give yourselves the credit for it as well, done a lot of the pioneering work in AI as well and are doing really exciting stuff. So I'm always looking interestingly to see what you guys at the Mayo Clinic are doing around AI-based ECG interpretation. Because we take a lot of inspiration from that over here. We're in Belfast at the moment, in Northern Ireland, so we keep a close eye on what you're doing and hopefully we can merge some of the great success you've had in the field.

Dr. Kashou: Well, thank you. As the field continues to evolve, it is evident that artificial intelligence will play an important role in clinical decision making in patient care. Especially in the field of cardiology. Understanding the benefits, limitations and utility of these models will be important to find the best route to integrate this technology into clinical practice. Dr. Kennedy, thank you for sharing your insights into device agnostic, AI-based ECG analysis. You're an expert on the topic and we look forward to your work in the future and hopefully have you back. On behalf of our team, thank you for taking the time out of your day to join us. It's been a true pleasure.

Dr. Kennedy: Thanks Anthony. Thanks for having us on and I'm happy to come back at any time.

Dr. Kashou: Thank you.

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