Fostering Innovation in Cardiology & Partnerships Between Engineers and Academics; Innovation into Products

Announcer: Welcome to the Mayo Clinic cardiovascular continuing medical education podcast. Join us each week to discuss the most pressing topics in cardiology and gain valuable insights that can be directly applied to your practice.

Dr. Kashou: 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. 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 look at how to foster an environment of ECG innovation. We'll be joined by one of the leaders in this field, who has succeeded in making this a reality at the Mayo Clinic. Before we get into our discussion with our guest, let me give you a little background on the topic. Nearly one century after the Nobel Prize was awarded to Willem Einthoven for demonstrating that an electrocardiogram or ECG could record the electrical signature of the heart, the ECG remains one of the most important diagnostic tests in modern medicine. Moreover, we are standing at the edge of true innovation in the ECG space. Simultaneous advancements in computing power, wireless technology, digitized data availability and machine learning have led to the development of artificial intelligence, augmented ECG models. These models have not only been able to replicate what a human can do, such as interpret an ECG but they have also demonstrated capabilities beyond what the expert trained eye can see, like detecting left ventricular systolic dysfunction. New models continue to be developed from researchers all around the world. This has naturally led to the need of professionals that are generally considered to have stark differences in background from medical providers, to engineers all coming together to work on this. This brings us to today's discussion, on cultivating an environment for ECG innovation. We will discuss the opportunities in this space, how to incorporate and recruit engineers to a medical center, including those challenges, as well as how to make ECG innovation scalable and widely available to patients. With that said, we are fortunate to have an expert in the field joining us, who has and continues to navigate this space successfully. Our special guest today is Dr. Paul Friedman. Dr. Friedman is a Professor of Medicine in the Norman Blane $ Billie Jean Harty Chair of the Department of Cardiovascular Medicine at the Mayo Clinic in Rochester, Minnesota. He's a trained electrical engineer with deep experience in innovation, with over 40 patents issued and named Minnesota Top Inventor. Furthermore, he has over 600 scientific original publications. Dr. Friedman is also a committed educator serving as a director for five national and international meetings, editor of seven textbooks and author of over 60 book chapters. He's a frequent visiting professor and lecturer at educational meetings. Some of Dr Friedman's interests include arrhythmia management, cardiac device insertion and extraction, remote monitoring, and artificial intelligence in medicine, which will be the focus of today's episode. Dr. Friedman, what a true honor to have you today. Thank you so much for joining.

Dr. Friedman: Thank you for having me.

Dr. Kashou: Now, there's a lot that I wanna discuss with you and we're kind of constrained to a limited amount of time. So let's get started here. Now, we know that the ECG has been around for over a hundred years now, yet we still use it every day in our practice and it spans across a variety of medical settings and specialties. It is quite remarkable to think that there might be real opportunities to still innovate in this space. So my first few questions that we have for you are, are there really opportunities for ECG innovation? And if so, what do those opportunities look like?

Dr. Friedman: Well, again, thanks for having me and thanks for the question. It's remarkable but the opportunity for innovation in ECG is huge. And if you stop and think about it, the traditional teachings we've all gone through in medical school are to look at ECG segments and then based on those segments make diagnoses, like is the left atrium enlarged, is the right atrium enlarged based on the duration of a specific P wave or segment. And you could ask what the clinician cares about. What the patient cares about is, do I have a treatable disease that I may not be aware of that the electrical recordings of my heart can identify? Now historically, acute MI, arrhythmias, the ECGs work perfectly. But there are a slew of other conditions as you mentioned, left ventricular dysfunction, amyloid heart disease, valvular heart disease other ones that the current diagnostic tests are powerful but they're expensive. Even in resource rich environments, they're limited, they're constraining. So if we had a way to find out who's harboring these diseases, before they become manifest, before someone shows up with shortness of breath or fainting spells, it would be a huge advance. And the way historically it would work is there would have to be so many myocytes affected that a segment, a name segment, a P wave would be affected. And the basic idea has been to use convolution neural networks to completely revolutionize that.

Dr. Kashou: And can you maybe speak a little bit about those networks maybe on a general scale?

Dr. Friedman: Sure. Yeah, yeah. So the idea is this, rather than saying we're gonna look and identify a segment and if it changes then experts who have done anatomic specimens and ECHO specimens and other studies say yes, it means a larger heart. Let's say we wanna know if someone has a weak heart pump or left ventricular dysfunction. Then what we'll do is we'll take say 50,000 or a hundred thousand ECGs, from individuals who also had echocardiogram at roughly the same time. And then we feed those into a computer, into what's called a convolution neural network where the network scans the image with convolution filters and then has a model to predict an output. And you start off by feeding in one ECG. The computer gets the voltage time input, and you say what's the ejection fraction? It has no idea. So it'll guess, it'll say 45%. And you'll say, no, this one is 35%. And what it does through a process of back propagation is it will tweak each of these so-called neurons which are just a very simple math equation, all interconnected in a model that's designed to mimic human cortex until it gets slightly closer. You feed in the next one. You do that again, it gets a little bit closer. You do that repeatedly and at the end of that process, it's now seen maybe 50,000 a hundred thousand, I mean, a large number of them. So then it becomes very, very good. The key point is that it takes a lot of ECGs and a lot of computing power to train the network, but once it's trained, it can run on a smartphone because it's a simple math equation. And then you can feed in an ECG and get out an answer and it becomes very, very powerful.

Dr. Kashou: You talk about almost like the continual learning process of, you know these networks, these neurons, like the brain and similar to almost how we learn, there's so much down that alley, and I don't wanna get too down far into it and go away from where we're planning, but you know, innovation and we speak about this a lot, can be fun to consider in the abstract sense, especially when you have colleagues in the same specialty who can easily see that vision. However, in this case, it seems like when working with engineers in this space, not only are you working with those, not in the same field but also not in the same profession. And you've been able to to navigate this successfully here at the Mayo Clinic. And I wonder if you could share a little bit of how those opportunities come about and those challenges in recruiting engineers to a medical center, such as here.

Dr. Friedman: I think that it really requires creating an ecosystem where everyone can contribute. And we all come to the problem, you know, with a different perspective. And one of the challenges has been in, you know historically hospitals have not recruited AI scientists, AI engineers. And so, you know, they consider them more IT or information technology. And it's very different just like in medicine, you wouldn't call a cardiologist, a gastroenterologist or an internist, We're very specialized, have different ways, and so the entire schema of how you recognize professional development and professional opportunities is critically different. I think the key is to have an overriding goal and vision. We wanna improve the human condition and we wanna use these powerful tools. And in a minute, we can come back to why ECG in particular is great for this. To try to diagnose disease before it becomes manifest. And so when you have that kind of ecosystem and a lot of different perspectives and historically we've had physicians and nurses and anesthetists and surgeons all in a medical ecosystem. And when we've inserted people who see the world differently, if we do it in a way that engages them, you know, a lot of magical things can happen. We typically start with an orientation. So we have our engineers go on rounds, watch procedures. I'll never forget when, you know, one of our first engineers joined me for an ablation and he just looked at me and goes, well why did you do that? And I was like, well, I was trained to do it that way. And he said, but why? And then we stop and we talk about it. And when you start getting to the basics, is when you can really start to make some new insights and new innovations. And having that culture of asking questions and working together and recognizing everyone's contributions takes time to build but then remarkable things can happen.

Dr. Kashou: Yeah, it's that other perspective, that as you mentioned, we go through our day to day activities and, you know we're gonna do, you know, this next ablation which is probably become routine for you, and that's the same outside of not only, you know your work, but now we see it in GI and other fields as well. And you mentioned the area for ECG innovation. In that area, maybe you could share what you were going to there.

Dr. Friedman: Sure. Yeah, of course. So we started off by doing the retrospective analysis that I referred to. So you name a condition, we have people with ECGs with it and then we have the computer find the correlations. And as I started to mention earlier, instead of having a name segment with a change, a P wave gets big or gets long. The computer makes its own connections. And it's called a black box, because we don't know what feature of the signal it's looking at. And likely by looking at a hundred thousand, a million ECGs it can pick up very subtle, non-linear,

interrelated, multiple connections that could tell it, this is what an ECG looks like from someone who has silent atrial fibrillation for example, even though the ECG is recorded during sinus rhythm or that they have ventricular dysfunction. It can identify these very subtle patterns but it really is pattern recognition. And then once that's done, you say, well how is that scalable? Well, think about this. The ECG is embedded in everybody's practice. And so as you know, one of our colleagues has done a clinical trial where they introduce the results of an AI ECG in primary care practice and because it's software, and because the test is already embedded in clinical practice, they were able to enroll over 20,000 people in a matter of months to determine can we find hidden disease? And the fascinating thing is even before symptoms arise, the ECG will change so you can detect a cult disease. And it turns out that for many conditions left ventricular dysfunction, aortic stenosis, many others, the ECG will change, because the pathology affects the ion channels before structural changes occur. So the AI ECG can pick up a disease often earlier than an ECHO or a CT, MRI. And so we're finding it a very good early warning test.

Dr. Kashou: It's amazing, you know, just thinking this again, over a century year old, we're still now seeing unlocked potential in this. And you mentioned the scalability of some of these ECG innovations and what's fascinating about technological advances, is that hard work upfront, you know, training these models, making it learn more. But what's nice is the potential for scaling it. You know, we know about the AI dashboard. Maybe you can mention a little bit about that and how we actually reach, you mentioned the study earlier more of the perspective, but how do we reach the, you know, people around the world with some of these innovations?

Dr. Friedman: Sure, so you refer to the AI dashboard. That was like many of these models created by our colleague Zachi Attia, and essentially it's a way of rapidly viewing an ECG. And then for a plotting for every person's ECG, what their risk at that point in time was for silent atrial fibrillation, aortic stenosis left ventricular dysfunction, and we keep adding new models to it. So it becomes a bedside tool or a clinic side tool that a clinician can get rapid experience with. We've opened it up within the Mayo system, it's currently undergoing regulatory approval and then once that happens, it can be made available at other sites on a commercial basis from via Mayo Clinic and Mayo Clinic platform. This other aspect of the scalability is that an ECG as you know, is available on a watch or a smartphone and early data suggests that there's a lot of diagnostic information and those other foreign factors as well. I guess the one comment I would make is as with any new medical test, we have to vet validate and verify, make sure it really works as we expect. And so the promise is huge, but there's also a big responsibility to make sure we don't make people needlessly worried, that we're getting the accurate diagnoses, that we know how to respond to the data. And as we have this growing experience from the dashboard, we become increasingly able to do just that to get a sense of, well, when we see this, we know it means X, Y, and Z and this is nothing to be concerned about.

Dr. Kashou: Yeah, it's incredible. And I can personally speak on the AI dashboard and using it clinically more as like you have a high pretest probability and you almost want that reaffirmation of is this truly there or not? You know, you find it most helpful. It's really incredible not only the work you're doing how you've been able to bring these people together. Now before we end, I always like to ask, you know, we know you've accomplished so much in your academic and professional year. I truly admire that and I know there's so many of us that do. Maybe you could share a little career or even personal advice that you share with those in medicine today.

Dr. Friedman: Well, first, you know, thank you. But it really has been a team effort. And I think what makes medicine exciting, what converts, you know, what we've all experienced maybe a difficult case from an interesting case, is when you have bright people surrounding you, who you can discuss it with. And all of a sudden it goes from being something that's a difficult challenge to something that's interesting and you think about new ways you can approach it. And I think, you know, one of the reasons I love working at Mayo Clinic is that we have so many talented people, and each bring something different. I mentioned, you know Zachi Attia who's brought AI engineering expertise. Peter Noseworthy has developed clinical trials and I know you've spoken with him and has really brought this from the bench to the bedside. Xiaoxi Yao has done so from the current center for the Science of Healthcare Delivery and each time we get together, Francisco Lopez, you met us, I can go on naming just a lot of people who've each brought a different perspective different talent, which really makes this possible. And so I guess my first advice would be to do something you love, do it with people who you admire and respect and who know more in different things than you do and you'll have a fulfilling and rewarding career. And certainly with the application of artificial intelligence to medicine, you know, it's an opportunity to do more. It won't replace us. The way I like to think of it is, because people often say, am I gonna be out of a job? And on the contrary, it's like, if you go for a walk at night, you can't really see very well but you pull out a flashlight and you can see into the distance, but it's still your eyes and your mind. And in many ways I think developing these tools, learning how to work with them, helping others work with them is exciting. And in that process, ultimately we can achieve our goal which is to improve human health. And so, I feel privileged to have exciting, interesting work that at the end of the day does hopefully some good in this world and to do it with people who I admire. So my only advice is as much as possible, do the same.

Dr. Kashou: Thank you so much. And it is the teamwork, as they say make the dream work. And it's true here that it is a team effort in all this. Advances in machine learning and computing methods have led to the development of artificial intel-enabled ECG models. With the opportunity for tremendous potential in the ECG space, some of these models have unlocked new value in the ECG. Some even have a chance to transform clinical workflow as well as patient screening, monitoring and management. Strategic development of teams with alliance from various disciplines is critical in continuing this progress and ensuring proper implementation to meet the needs of the patient. What an exciting time we are living in and how lucky we are to witness this process firsthand at the Mayo Clinic. Dr. Friedman, thank you for sharing your knowledge and expertise in this field. You are truly a pioneer and leader in this space and someone that is making this all come to life. 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. Friedman: Thank you so much.

Dr. 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 to a Mayo Clinic Cardiovascular CME podcast on your favorite platform and tune in every other week to explore today's most pressing electrocardiography topics with your colleagues at Mayo Clinic.
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