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Patching Up Cardiovascular Risk

Dr. Brown:
Could tracking cardiovascular risk really be as easy as wearing a patch? Welcome to *Heart Matters* on ReachMD. I'm Dr. Alan Brown, and joining me to discuss his team's recent development in cardiology is Sheng Xu, Professor of Nanoengineering, Bioengineering, Computer and Electrical Engineering at the UC San Diego Jacobs School of Engineering. Welcome to the program.

Professor Xu:
Thank you very much, Dr. Brown, for the opportunity.

Dr. Brown:
So, I understand from our discussions just before the interview that, you know, you've developed an ultrasonic patch and you explained to me a little bit about the fact that when people do ultrasound with hand-held probes, it requires a lot of different angulation to get appropriate imaging and it's somewhat dependent on the technician, in terms of measurements and quality. So, let's start with what inspired you and your team to work on developing an ultrasonic patch.

Professor Xu:
Well, that's a great question. I come from a materials background and specifically I was introduced to the field of wearable electronics when I was a post-doc at the UIUC Urbana-Champaign. I spent quite a few years, you know, doing research on wearable patches. And then later when I did a deep dive into the literature on wearable electronics I noticed that conventional wearable patches can sense a lot of signals from the human body but they all have a common denominator. Those wearable patches can only sense signals on the skin's surface, or shallow into the human body. So, for example, they can measure temperature, measure the sweat content, measure the interstitial fluid, measure the stress, right? Or if you shine those light into the skin say for example some of you may wear those Fitbit or Apple watch on the backside of the device there may be a blinking light source, right? Those light source can only penetrate a few millimeters into the human body, measuring the capillary pulse ox, right? So, that means existing wearable devices, no matter is a commercial device or researching prototypes in academia, they can only sense the signals within one centimeter below the skin surface. However, they are a lot of more activities, events going on under the skin surface. And the most of the time, those activities, have direct correlation with some of these pathological processes events, right? So, question boils down to how can we probe, how can we access those deep tissue signals, central organs using a wearable patch?

Dr. Brown:
Yeah this is really fascinating. One of the things that we talk about in the future of healthcare is that we want to be able to monitor people in real time with wearables. Wouldn't it be nice to know the day your PSA goes up rather than wait 'til your once-a-year appointment when somebody decides to draw a blood test, right? And so it's more than. I know people are fascinated with what the Apple watch could do, but probably the future of healthcare is gonna be monitoring people at home with wearables, having a big dashboard of patients that we're committed to promoting health for them and when we notice that something is abnormal, we'll know it immediately and can act on it much earlier than waiting for symptoms to develop or testing. Does that make sense with your interest in wearables?

Professor Xu:
Exactly. Wearables can empower each one of us, you know, manage our own health, right? As you said, those conventional healthcare is based on intermittent. Those infrequent hospital visits or until those symptoms show up, right? So, wearables enable continuous monitoring prognose the onset of the symptoms and that give us a lot of time to provide a timely intervention before this health outcomes exacerbate. So, that can potentially save a lot of costs and lives.

Dr. Brown:
Yeah. So, with that background, tell us a little bit about ultrasound patch. So, I think we're all familiar, as you mentioned with the Apple watch and other sensors like a pulse oximeter, but you've developed a patch that actually does ultrasound as a wearable. Tell us a little bit about how that patch works.

Professor Xu:
Well, good question. So, conventional ultrasound probes are pretty thick with like those bulky transducers many electronics embedded inside. So, we engineered the ultrasonic patch in a such a way that we reduced the dimension of those components so that everything is within, like, 1 to 2 mm in thickness. And this patch is like as soft as the human skin. It can laminate, you know, integrate with a human body intermittently and can formally enable those continuous monitoring when the patient is like in motion or when they are away from hospital. So we do need like a developmental platform to control those ultrasonic patch. And this, connection between the ultrasonic patch and this developmental platform is connected by a flexible ribbon-based cable. As a next step, we are aiming to integrate those developmental platform together with the wearable patch, so that it is tether-free, it is cableless.

Dr. Brown:
Yeah that's amazing. What were you thinking in terms of what types of things would you be monitoring with this ultrasound? When you were developing this, what organs did you have in mind for monitoring and what would the benefit be as you see it to the patient to have continuous ultrasound monitoring via a patch?

Professor Xu:
We are particularly interested in cardiovascular disease because it's a number one risk factor. And we are looking at the hypertension by imaging the vessel, dilation, the vessel diameter. And we use A-mode to continuously track the vessel diameter. And through a series of well-established correlations, we can convert the vessel diameter to those blood pressure wave forms calibrating the systolic blood pressure and the diastolic blood pressure against a cuff that we can measure. Beyond that we also started the echocardiography, right, we can continuously track the left ventricle, the right ventricle wall chamber activities because the myocardium contractility and relaxation, you know, beat-to-beat.

Dr. Brown:
So, what, kind of, clinical outcomes have you seen with this patch? You mentioned correlating it with blood pressure and possibly looking at solid organs for progression of disease. What sort of things have you been able to evaluate so far?

Professor Xu:
We have been able to evaluate a couple of things. The first thing is, continuous blood pressure waveform in both the arteries and veins and the clinical outcome is that those blood pressure waveforms are conventionally wearable only by invasive methods. I'm sure, Dr. Brown, you know, those, waveforms, essential blood pressure waveforms can only be measured by invasive A-lines, like catheters, right? So, that has a lot of risk, for infection for, you know, complications for the patients. And they also takes time for the clinicians to do that, right? So, I think with this wearable ultrasonic patch, it just have to slap this patch at the location where you want to measure the waveform, then the patch will start to record this waveform by itself without breaking the patient's skin.

Another thing that we can record is blood flow velocity using color Doppler waveform. And beyond that we can also record this heart chamber wall motion. All based on this patch on the skin surface, non-invasively and continuously.

Dr. Brown:
So, this is really fascinating. One could imagine putting one on your neck and evaluating the carotids, etc. Today we were talking primarily about cardiovascular disease. What other aspects of the ultrasound could be useful in identifying early or helping us prevent cardiovascular illness?

Professor Xu:
That's a fantastic question. We are closely working with the clinicians trying to, you know, find out the, you know, clinical significance of this technology. So, based on our initial interactions with the clinical collaborators here at UC San Diego, we understand that say for example for those heart failure patients there have been, evidence showing that the central blood pressure waveform those blood pressure in the pulmonary artery has a much stronger and earlier prognosis of power than those blood pressure on a peripheral vessels, right? And that means if you can monitor the central blood pressure. waveforms, say for example pulmonary artery, then you can know much earlier the onset of this heart failure. So, then you can, you know, save precious time to apply, you know, interventions, you know, save the patient's life.

Dr. Brown:
Great. That's fascinating. I really appreciate the work that you're doing and I think all of us could imagine what the opportunity is with a wearable ultrasound and also one that is wireless and allows remote monitoring. So, I really appreciate you sharing all this with us. This is certainly and exciting step in early identification of not only cardiac problems but probably other systemic diseases. And I'd like to thank Professor Sheng Xu for joining me for this very important discussion. It was great to have you on the program and congratulations on your work.

Professor Xu:
Thank you, Dr. Brown, for having me.

Dr. Brown:
For ReachMD, I'm Alan Brown. To access this and other episodes in our series, please visit ReachMD.com/HeartMatters where you can Be Part of the Knowledge. Thanks so much for listening.