

New technique diagnoses non-periodic arrhythmias in a single heartbeat

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Thanks to a new study from Columbia Engineering School, doctors may now be able to diagnose in their offices non-periodic arrhythmias—noninvasively and at low cost—within a single heartbeat. Non-periodic arrhythmias include atrial and ventricular fibrillation, which are associated with severely abnormal heart rhythm that can in some cases be life-threatening.

Using Electromechanical Wave Imaging (EWI), a technique recently developed at Columbia Engineering, the researchers sent unfocused ultrasound waves through the closed chest and into the heart. They were able to capture fast-frame-rate images that enabled them—for the first time—to map transient events such as the electromechanical activation that occurs over a few tens of milliseconds while also imaging the entire heart within a single beat. The Columbia Engineering study was recently published in IOPscience ("Electromechanical wave imaging for arrhythmias," *Phys Med Biol.* 2011 Nov 21;56(22):L1-L11, <http://www.ncbi.nlm.nih.gov/pubmed/22024555>).

"We are very excited about extending the capabilities of our new technique," says Elisa Konofagou, an associate professor of biomedical engineering and radiology at Columbia University's Fu Foundation School of Engineering and Applied Science. "With EWI, doctors now won't have to use electrodes to detect and localize those unpredictable and potentially deadly arrhythmias and they'll be able to do this at the point of care, not only in a dedicated, interventional procedure room."

She adds that, "For the first time, EWI can be implemented without relying on multiple periodic heartbeats for the high temporal resolution imaging required. A single heartbeat, whether periodic or not, will suffice by employing tailored beamforming sequences and signal processing techniques."

Konofagou explains that the heart is essentially an electromagnetic pump that must first be electrically activated in a specific sequence to contract and relax efficiently. Abnormalities in cardiac conduction are a major cause of death and disability around the world and their prevalence is expected to rise with the aging of the population. The number of people in the U.S. with atrial fibrillation (AF), the most common arrhythmia, is expected to reach 12 million by 2050. AF causes 15 to 20 percent of strokes and costs \$6.65 billion a year to treat.

EWI is a novel ultrasound-based technique that Konofagou and her team developed earlier this year to map electromechanical waves, the transient deformations occurring in immediate response to the electrical application. They were able to map these waves by reconstructing images over multiple cardiac cycles but this method did not allow them to image non-periodic [arrhythmia](#) such as fibrillation. In the new study, the researchers developed and applied new imaging sequences based on flash- and wide-beam emissions to image the entire heart at very high-frame rates (2000 fps) during free breathing in a single heartbeat.

"Potential applications of this technique include early, reliable, and electrode-free detection and diagnosis of arrhythmias and localization of arrhythmic origins to guide subsequent ablations," notes Konofagou. "For example, atrial flutter is a condition of arrhythmic activation of the atria. Physicians have to perform radio-frequency ablation to reinstate its function but often they don't know if it's the right or the left atrium. So, they start ablating the entire right atrium only to find out that the left atrium was causing the flutter, administering unnecessary treatment in

the process. By pushing the current capabilities of our technology further, we can help doctors make more noninvasive diagnoses and treat the patient more efficiently."

Provided by Columbia University

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