Calculating a dangerous heartbeat

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How ventricular fibrillation will behave in an individual patient can be accurately modeled and predicted using a single mathematical equation, according to Flinders University researchers.

Ventricular fibrillation (VF) is a life-threatening heart rhythm, or

arrhythmia, that causes the heart to beat irregularly and is one of the leading causes of sudden death in Australia.

The findings, recently published in the journal *Heart Rhythm,* could be used to improve patient treatment, including identifying when to intervene or to develop individualized treatment plans that can work more effectively.

Developed by Dr. Dhani Dharmaprani from the Flinders Heart Rhythm Research Group in the College of Medicine and Public Health, led by Associate Professor Anand Ganesan, the research team studied the statistical properties of VF, identifying the unique patterns that consistently occurred in human patients, as well as animal and computer models of VF in the heart.

"The issue we have with VF is that because the rhythm is so chaotic it's been very difficult to fully understand the mechanisms that are responsible for the disorder," says Dr. Dharmaprani, a Biomedical Engineer and Postdoctoral Research Associate in Cardiac Electrophysiology.

"This is further complicated by the fact that everyone's heart is unique, so how the heart reacts during VF changes from patient to patient.

"However, by identifying the characteristics that consistently occurred, we were able to demonstrate for the first time that a single mathematical equation could be used to accurately model and then predict the behavior of VF."

The equation uses principles from a branch of mathematics known as renewal theory to predict the population dynamics of "rotors"—mini tornadoes of electricity found in the heart during VF. These rotors are responsible for giving rise to VF's chaotic heart rhythm, and therefore

understanding their dynamics is central to treating the disorder.

The researchers say when applied, the equation could be used to improve patient care in two distinct ways.

"Firstly, the equation seems to predict whether fibrillation will continue to persist, or whether it will stop on its own, this could be important as it could help us identify between patients that require treatment and those where no intervention is needed," says senior author Associate Professor Anand Ganesan, a practicing cardiologist and Matthew Flinders Fellow in Electrophysiology at Flinders University.

"Secondly, because the mathematical equation can model how an individual patient will react to VF, we can use it to potentially develop individualized treatments that work much more effectively."

Previous research has also demonstrated the equation can be applied to atrial fibrillation (AF), another form of heart arrhythmia that is the most common in the world.

The next step for the research team is to translate these findings towards potential therapies, including using the equation to develop patient specific computer models that accurately replicate patient dynamics, and understanding how this equation relates to clinical characteristics.

More information: Dhani Dharmaprani et al, A governing equation for rotor and wavelet number in human clinical ventricular fibrillation: Implications for sudden cardiac death, *Heart Rhythm* (2021). DOI: 10.1016/j.hrthm.2021.10.008

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