Researchers find that electrical function may be restored in damaged heart tissue

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Credit: Dalhousie University

A Dalhousie Medical School researcher has discovered that scar tissue, like that caused by a heart attack, can maintain electrical function in damaged regions of the heart. Until now, scars in the heart were thought to only disrupt the electrical activity needed for a normal heart beat. The finding was recently published in *Proceedings of the National Academy*

of Sciences.

"This is the first direct evidence that electrical connections between scar and healthy tissue occur in the heart," says Dr. Alex Quinn, assistant professor in the Department of Physiology & Biophysics. "This finding really turns our current understanding of the heart's electrical activity on its head, and may open the door to much needed improvements in treating many cardiac diseases."

Heart attacks deprive heart cells of oxygen, causing the cells to die and be replaced by scar tissue. And although scars help maintain the structure of the damaged heart, they disrupt the electrical connectivity needed for it to pump blood normally.

"Basically, scars act as walls that interrupt the typical electrical activity of the heart. As a result, the heart pumps in an irregular pattern," explains Dr. Quinn. "This electrical disruption is called an arrhythmia, which can lead to sudden cardiac death or heart failure."

In collaboration with researchers in Germany, the United Kingdom, and the United States, Dr. Quinn has shown that under certain circumstances, scar tissue can be electrically charged by the surviving heart muscle.

"If we can steer cells in the scar to purposely connect with cells in the healthy heart tissue, we may be able to eliminate the torturous paths that cause abnormal heartbeats to develop. Instead, we'll have nice, smooth conduction," says Dr. Quinn. "This could have significant implications for rehabilitating patients after a heart attack."

The researchers also identified tiny tunnels, known as nanotubes, between scar tissue and healthy heart cells, which may explain how they electrically unite.

Healing the heart using its own mechanisms

Most research focuses on rebuilding the heart by making new muscle to replace damaged tissue. However, this study suggests it may be more effective to work with the heart's own repair mechanisms, by manipulating the electrical connections that can form between healthy and scarred tissue.

"The study suggests that we may be able to mend the broken heart by helping it to generate 'better scars,'" says Dr. Peter Kohl, director of the Institute for Experimental Cardiovascular Medicine at Freiburg University, Germany. "This would build on nature's inherent repair mechanisms, and might offer a more practical route to improving cardiac wellbeing than the – so far cumbersome – path of trying to make new muscle."

Manipulating the electrical activity of scars could also help improve procedures for atrial fibrillation, which is one of the most common types of heart arrhythmia – especially in older patients.

Ablation, a technique in which scars are purposefully created in the heart to interrupt stray electrical waves, is currently the most effective treatment for atrial fibrillation. Ablation scars, however, become ineffective in upwards of two thirds of patients within months of the procedure. This may be accounted for by the electrical connections between healthy heart muscle and scar tissue seen in this study.

"If we can learn to control these electrical connections – so that we can increase or decrease them as needed – it may be possible to reduce the number of repeat interventions for people requiring treatment for some kinds of heart disease," says Dr. Quinn.

More information: T. Alexander Quinn et al. Electrotonic coupling of

excitable and nonexcitable cells in the heart revealed by optogenetics, *Proceedings of the National Academy of Sciences* (2016). DOI: 10.1073/pnas.1611184114