German researchers use light to make the heart stumble

October 4 2010

Tobias Brugmann and his colleagues from the University of Bonn's Institute of Physiology I used a so-called "channelrhodopsin" for their experiments, which is a type of light sensor. At the same time, it can act as an ion channel in the cell membrane. When stimulated with blue light, this channel opens, and positive ions flow into the cell. This causes a change in the cell membrane's pressure, which stimulates cardiac muscle cells to contract.

"We have genetically modified mice to make them express channelrhodopsin in the heart muscle," explains Professor Dr. Bernd Fleischmann of the Institute for Physiology I. "That allowed us to change the electric potential of the mouse heart at will, enabling us to selectively produce conditions such as arrhythmia of the atrium or the ventricle."

These types of arrhythmia - physicians also call them ventricular fibrillation - are among the most common causes of death after a heart attack. They develop when large quantities of cardiac cells die and are replaced with connective tissue. "This scar tissue has a different electrical activity than the healthy heart muscle," says the leader of the study, Professor Dr. Philipp Sasse. "And that makes the heart stumble."

But why is that so? Normally, electric impulses spread across the heart from a natural pacemaker. This happens in a temporally and spatially tightly controlled manner, creating a closely coordinated contraction. However, if entire muscle areas decouple electrically, this mechanism no longer works: all of a sudden, certain parts of the heart pulse at their own

rhythm. This causes the blood flow to come to a near-standstill.

The scientists from Bonn can now trigger this decoupling through photostimulation. They can target just a few cells at a time or direct larger areas of the heart, allowing them to find out, for instance, which areas of the hollow muscle are especially sensitive to electric disruptions.

But why not simply stimulate the heart muscle with electrodes in order to make the heart lose its rhythm? "That can be done as well," says Professor Sasse. " But this method has unwanted side effects: if the electric stimulation lasts longer than a few milliseconds, toxic gases are produced, and the pH value changes."

The consequences of a heart attack, which leads to permanent tissue damage, can of course only be studied in a very limited form when using short-term electric stimulation. Photostimulation is much more suitable: the cells will even withstand stimulations of several minutes at a time without problems.

Using channelrhodopsin in medical research is not fundamentally new, although so far it has mainly been used in neuroscience. For instance, scientists can use these light channels to direct the behavior of flies and mice - with nothing but blue light.

Provided by University of Bonn