Light could replace shock to regulate hearts

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So many Americans experience dangerous fluctuations in heartbeat that about 400,000 times a year a device is implanted in their chests to keep a normal rhythm.

But the defibrillators that send a life-saving electric buzz through the heart can be so painful and damaging that scientists have been looking for a better way. At the Johns Hopkins University in Baltimore, researchers believe that a mellow ray of light could someday replace the electricity.

"We're using explosives to open a door for which we have no key," said Natalia Trayanova, a professor in Hopkins' department of biomedical engineering. "We're hoping this is the key."

Her goals are still a bit "pie in the sky," said Trayanova, who directs the Computational Cardiology Lab within the Institute for Computational Medicine. The research is relatively new - it melds study of the heart and optogenetics, or the use of light to control nerve cells, a science just over a decade old.

In the next 10 years it could replace conventional therapy that uses electricity delivered from a small box containing a battery and a computer chip implanted in the chest.

Called an implantable cardioverter defibrillator, or ICD, the box connects to the heart through wires and electrodes. When heart rhythms become irregular, the computer sends small electrical pulses. If this fails

to regulate the beat, a larger shock similar to one delivered by the paddles in a hospital attempts to reset the heart's rhythms.

Doctors say defibrillators are the gold standard for treatment and highly successful. Though the implantable devices developed in the 1980s are now the size of a pocket watch, there are drawbacks. They include pain, damage to heart tissue, batteries that need replacing, potentially faulty wires and anxiety about when the big kick will come.

The new Hopkins research is being done exclusively on a "virtual" heart generated by a room-size computer more powerful than 500 of the best commercial laptops. Building on their own work and that of others, researchers at the university are figuring out how to develop a device that is safe and effective long term.

In theory, doctors could someday identify the source of heart trouble and target specific cells by injecting a benign virus carrying genetic codes for light-sensitive proteins called opsins, or by implanting opsin-rich cells produced in the lab. When a heart beats irregularly, called an arrhythmia, a device would send light over opsins in the modified heart cells, passing a small electric current and synchronizing the erratic heartbeats.

So far, the most advanced work in optogenetics has been done in the brain, and studies have shown that rats with modified cells will turn left, for example, when a light is turned on. That control could someday be harnessed to control Parkinson's tremors or epilepsy seizures, the researchers said.

With the heart, those at risk for sudden cardiac arrest, one of the leading causes of death in the United States, could be saved with a light source tailored to their heart condition, perhaps in the next decade or so. Even children with conditions or genetic predispositions could have their cells modified in preparation for treatment. The opsins would remain dormant

without light, the researchers said.

"If we can do this in a model, then there are (live) experiments worth doing. And we're narrowing what experiments would need to be done," said Patrick Boyle, a postdoctoral fellow working with Trayanova on the project. "It's a steep hill to climb. If this all works, it will be a game-changer."

Kathleen T. Hickey, an assistant professor at the Columbia University School of Nursing, agrees that replacing current technology would be beneficial to patients who fear pain and being unprepared for a large shock. Some worry that their implantable defibrillators might not function or might go off unnecessarily while they are exercising and have an elevated heart rate.

Hickey advocates that nurses provide additional counseling before and after a patient gets a shock. She has been working with her university and other professionals through the American Heart Association.

"We've found counseling goes a long way in decreasing anxiety," she said. "The patients benefit from knowing what the device will do and won't do."

She said a light-based implant could reduce side effects, the stress on patients and their families, and the amount of anti-arrhythmia medications used.

Other researchers are working on ways to reduce the large jolt of electricity now used, said Dr. Douglas Zipes, a professor of medicine at Indiana University 's Krannert Institute of Cardiology and a past president of the American College of Cardiology.

He said another promising avenue involves small, simultaneous shocks to

various parts of the heart instead of one large shock. But he said he is excited about Trayanova's work because it is potentially transforming in the way it would regulate heartbeat.

"We've been able in the last 30 to 40 years to reduce mortality by 50 percent," he said of past advances in heart care, including defibrillators. "If we can reduce the amount of energy and achieve the same end result as this optogenetics approach may facilitate, it would be very useful."