How 3-D Printing is Enabling Custom Cardiac Implants

Posted in Implantable devices by Thomas Klein on March 20, 2014

Custom cardiac implants might be the next big step in the production of pacemakers and defibrillators.

No two human hearts are alike, and that's not just a metaphor. They differ in size and shape, and that sets certain limits to the more or less 'one-size-fits-all' approach of today's cardiac implants. But these days might come to an end. Modern medical imaging, together with stretchable electronics and—yes—3-D printing, provide a promising approach to developing highly individualized cardiac implants.

One of the big downsides of today's implants is that they are basically developed as a 2-D sheet that then will be wrapped around the heart. Lizhi Xu of the University of Illinois, Sarah R. Gutbrod of Washington University in St. Louis, and colleagues pointed out in their Nature Communications article that these devices, "cannot cover the full epicardial surface or maintain reliable contact for chronic use without sutures or adhesives." Anyone who has tried to giftwrap a rectangular or oddly shaped present can relate to this problem.

The researchers' approach was to create images of animal hearts and print them out using a 3-D printer. Afterwards, they placed stretchy electronics around the model and coated them with an FDA-approved polymer. This layer then delivered a perfect fit for the real, beating heart, providing a mechanically stable biotic/abiotic interface during normal cardiac cycles.

This technique also allows for the vast improvement of electronics in the design: Implanted defibrillators today use readings from just one or two electrodes to determine whether to restore a normal heartbeat by applying an electric shock. With this little information, the system easily can make the wrong call, giving the patient a painful, unnecessary shock, as Igor Efimov points out. Efimov, cardiac physiologist and bioengineer at Washington University in St. Louis, is listed as one of the two corresponding authors of the Xu/Gutbrod-article, the other being flexible electronics pioneer John Rogers, a materials scientist at the University of Illinois at Urbana-Champaign.

"The next step is a device with multiple sensors, and not just more electrical sensors," says Efimov. The list of possible usages is long. Examples range from actuators for electrical, thermal and optical stimulation to sensors for pH, temperature and mechanical strain. They could deliver early signs of a blocked coronary artery as well as provide information about heart-tissue health and help detect heart attacks, which accumulate the fluorescent enzyme NADH.

The method so far has been tested on rabbit hearts outside the body. Further development efforts will center on demonstrating that these implants can also work inside an animal's body.

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