Stretchable Electronics Simplify Cardiac Ablation Therapy

In an improvement over open-heart surgery, cardiologists are now using catheters to eliminate damaged heart tissue in certain patients, such as those with arrhythmias. However, this can also be a long and painful procedure as many catheters, with different functions, need to be inserted sequentially. An interdisciplinary team that includes researchers from Northwestern University has now developed one catheter that can do it all. This tool for cardiac ablation therapy has all the necessary medical devices printed on a standard balloon catheter: a device for eliminating damaged tissue using heat, temperature and pressure sensors, an LED and an electrocardiogram (EKG) sensor.

Potentially, the multi-functional catheter makes a minimally invasive technique for heart surgery even better, as both diagnostic and treatment capabilities are combined. The stretchable electronics developed by Yonggang Huang of Northwestern and John Rogers of the University of Illinois at Urbana-Champaign make it possible.

"The use of one catheter to achieve all these functions will significantly improve clinical arrhythmia therapy by reducing the number of steps in the procedure, saving time and reducing costs," said Huang, Professor of Civil and Environmental Engineering and Mechanical Engineering at Northwestern. He led the Northwestern portion of the work.

In conversation with collaborating cardiologists, Moussa Mansour, M.D., of Harvard Medical School; Marvin Slepian, M.D., of the University of Arizona; and Joshua Moss, M.D., and Brian Litt, M.D., of the University of Pennsylvania, Huang and Rogers recognized that their stretchable electronics could improve the surgical tools currently used in cardiac ablation therapy. This procedure is used to cure or control a variety of arrhythmias, or irregular heartbeats.

The electronics Huang and Rogers use in this study are based on a "pop-out" design of interconnects, similar to their early design for stretchable electronics but with much larger -- approximately 130 percent -- stretchability. The type of arrhythmia the team focuses on is tachycardia, when the heart beats too fast.

This ability of the electronics to stretch is important because the researchers print all the necessary medical devices on a section of a standard endocardial balloon catheter where the wall is thinner than the rest. There the sensitive devices and actuators are protected during the catheter's trip through the body to the heart. Once the catheter reaches the heart, the catheter is inflated, and the thin section expands significantly, so the electronics are now exposed and in contact with the heart.

"Our challenge was how to make the electronics sustain such a large stretch when the thin wall expands under pressure," Huang said. "We devised what we call a 'pop-out interconnect' that performs very well. We didn't expect the electronics to sustain a stretch nearly three times the section's length."

Once the catheter is in place, the individual devices can perform their specific tasks. The pressure sensor determines the pressure on the heart; the EKG sensor monitors the heart's condition during the procedure; the LED sheds light for imaging and also provides the energy for ablation therapy to eliminate the tachycardia-inducing tissue; and the temperature sensor controls the temperature so as not to damage other, good tissue.