Nature | Health

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By Zeeya Merali

Researchers have developed a multifunctional catheter fitted with malleable electronics that has many of the necessary tools for cardiac surgery. The semiconductor device may help to reduce the length of heart operations and provide high-resolution, real-time brain mapping.

Catheters with inflatable tips are routinely used in heart surgery to unblock clogged arteries and insert artificial tubes. "But those balloon catheters do not have any active surgical power," says John Rogers, a materials scientists at the University of Illinois in Urbana-Champaign. "They are just dumb mechanical instruments."

During open-heart surgery, catheters with different functions often have to be inserted sequentially, making procedures long and painful. To improve catheter performance, Rogers and his colleagues have integrated a selection of stretchable semiconductor components onto its inflatable tip. Details of their device, which can monitor features such as temperature, pressure, blood flow and electrical activity, and can also remove damaged tissue, appear in Nature Materials this week.

The researchers' biggest challenge was to develop "stretchy electronics" made from rigid and brittle silicon that could be integrated onto the membrane of a standard balloon catheter, says Rogers. The key was to make the silicon components just one-hundred-billionths of a metre thick -- a thousand times as thin as usual. These were connected with serpentine-shaped wires that buckle and change shape as the balloon inflates, rather than fracturing. Once the balloon inflates, the electronic devices are pushed into contact with the heart.

"With these two features, you can make an integrated device that can stretch by up to 300%, from flat to spherical, completely reversibly," says Rogers.

The multifunctional balloon catheter is ideal for quickly diagnosing and treating the cause of irregular heartbeats, says Rogers. Currently, heart surgeons map tissue using pointed catheters with electrodes, which they move around slowly and carefully. When they find the abnormal tissue that can cause irregular heartbeats, they must insert a separate pointed catheter to remove it. "Most deaths during these procedures arise because of the time this takes," says Rogers.

Mapping the beat

By contrast, the modified balloon catheter can bring electronics into contact with a large surface area when it inflates, providing fast, high-resolution mapping, says Rogers. The team has used its device to map the beating heart of a rabbit and remove tissue by delivering a radio signal to heat and kill cells. "Human trials with a simplified version of the device, which cannot heat tissue, could begin as early as this year," says Rogers.

Christopher Ober, a materials scientist at Cornell University in Ithaca, New York, describes the work as a "technological tour-de-force". "To develop an integrated device that is truly flexible on such a small scale is spectacular," he says. He notes that the device could also be adapted to make implants that monitor the long-term health of organs. "But first, the team must test that it retains its biocompatibility over longer times."

The team is now adding more sophisticated components to the catheter, so that it can be adapted for use in other parts of the body. "It could be used in the bladder to monitor stretch and flow, or in the lungs to monitor the risk of an asthma attack," says Brian Litt, a neurologist at the University of Pennsylvania, Philadelphia, and another author of the paper. The researchers have also begun to create real-time maps of electrical activity in the brain during epileptic seizures. "The balloon catheter