Biosensors

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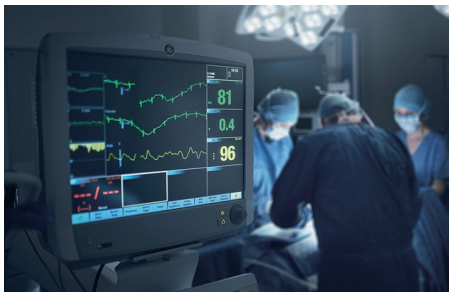
Bioresorbable microneedles track organ health



Assessing organ status intra- and postoperatively is crucial to ensure patient recovery and monitor post-surgical complications. However, standard clinical tools can fall short; blood tests may only pick up complications after substantial physiological damage has occurred, are not always specific to an organ and can suffer from confounding variables, whereas radiological exams can provide only a single data point at a time and require specialized facilities.

Now, writing in *Nature Biomedical Engineering*, Wei Ouyang and colleagues present a bioresorbable flexible microneedle sensor array for continuous monitoring of organ function for at least 7 postoperative days. The system remains affixed to the organ while enabling spatial mapping and the direct measuring of multiple biochemical markers. Once monitoring is complete, the device can be programmed to self-destruct through remotely triggered dissolution of the sensing electrodes.

The microneedle sensor array is fabricated by a photolithography-free, deformation-coupled 3D-printing-based process, which enables the formation of backward-facing barbed needles that allow seamless and stable interfacing with organs. Using double moulding and transfer printing, the microneedle patterns are then transferred from the 3D-printed resin to bioresorbable poly(lactic-co-glycolic) acid (PLGA). Using this approach, each microneedle in the array is individually addressable and can be coated with electrode materials for electrochemical measurement of distinct biomarkers, including metabolites, pH, electrolytes, tissue oxygenation and electrophysiological activity. "This combination of individual measurements within one array is important, because complications, such as ischaemia, hypoxia, metabolic stress, inflammation and motility disorders, typically do not show up in one single readout," says Xiangling Li, first author of the article.

Power and read-out are provided by a wireless electronics module that is mounted on the user's skin and linked to the array through a bioresorbable electronic suture with parallel electrical interconnects. "This design allows the electronics to remain outside the body, eliminating the need to implant non-bioresorbable components that would require a secondary surgery for removal," explains Li. Once the device is triggered to self-destruct, it degrades rapidly, becoming undetectable after approximately three weeks.

In rodent models of both acute and chronic kidney ischaemia, a common surgical complication arising, for example, from impaired blood supply or transplant rejections, the multiparametric microneedle sensor can monitor renal metabolism. In addition, postoperative gut disorders, such as anastomotic leaks or infection, can be detected by the sensor, demonstrating that concurrent assessment of multiple biomarkers enables accurate organ status monitoring.

However, translating this technology to humans presents several hurdles. "One key challenge is extending sensor stability from about one week to multiple weeks or even months," explains Li. In addition, clinical translation will require reproducible manufacturing, extensive safety validation, large-animal studies and regulatory approval. "Nevertheless, the core design principles, that is, soft bioresorbable materials, minimally invasive microneedle sensing and wireless monitoring, provide a strong foundation for further development toward human applications," adds Li.

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The team are also developing new sensing mechanisms and anti-fouling coatings to improve sensor stability, lifetime and bioresorbability. "We are expanding the range of biomarkers that can be measured to molecules, such as cytokines and pharmaceuticals, which could provide deeper insights into inflammation, immune responses and drug pharmacokinetics," says Ouyang. Additionally, the researchers hope to validate their prototype in further clinical scenarios to broaden its impact in critical care medicine.

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