Flexible sensor-integrated RFA needle leads to smarter medical treatment

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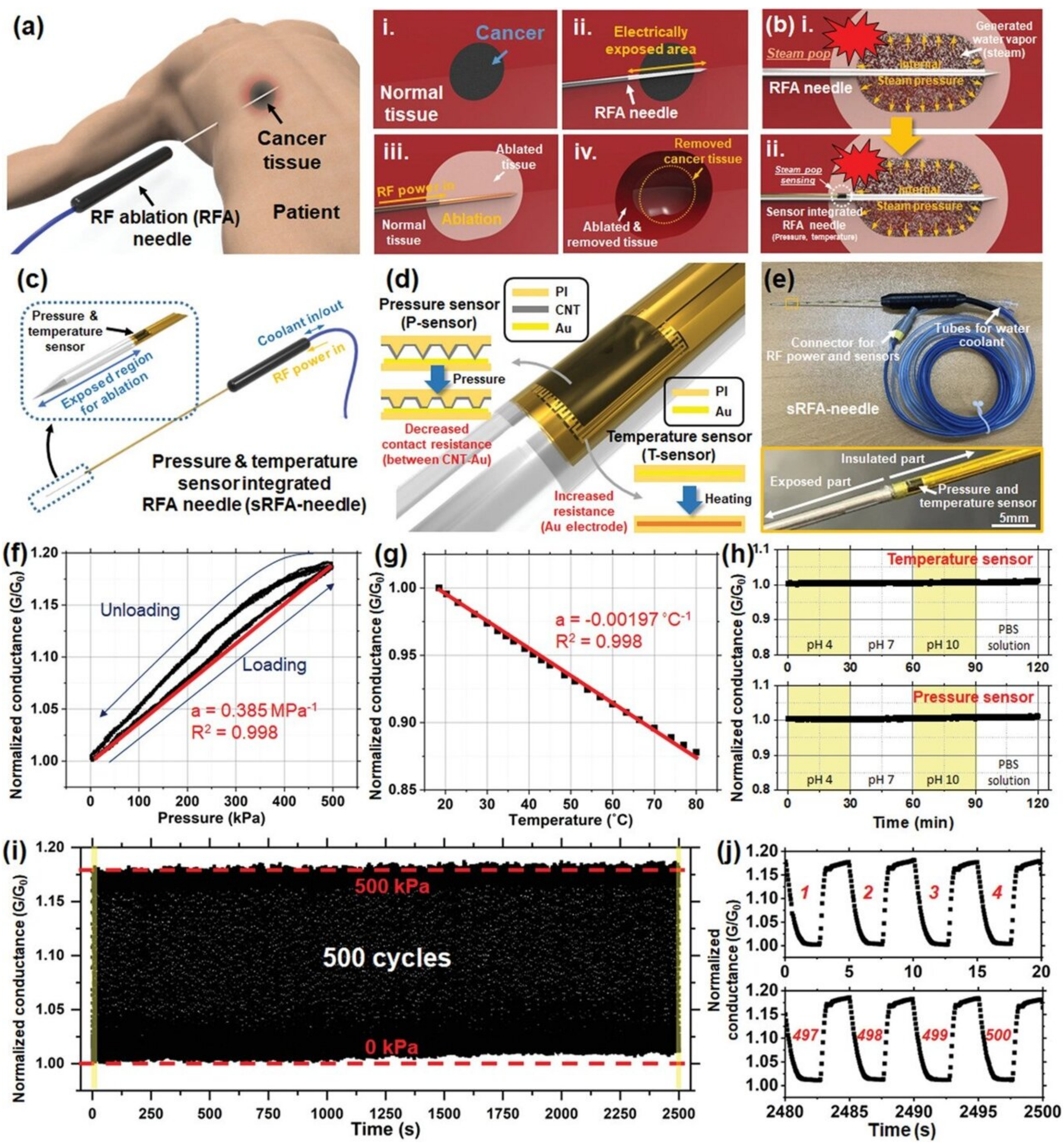

Schematic of RFA procedure and sRFA-needle and characteristics of the sensor on the RFA needle. a) Schematic of the RFA procedure to remove cancer tissue in patients: i) cancer in the normal tissue; ii) insertion of RFA needle through cancerous tissue; iii) application of RF power to the RFA needle and ablation of the tissue due to the increased temperature; iv) removal of cancerous tissue after the RFA procedure. b) Schematic of the steam pop phenomena and proposed sRFA-needle to detect and monitor steam pop. c) Schematic of the overall system for the sRFA-needle. d) Schematic of the working principles of contact resistance-based P-sensor and resistance-based T-sensor. e) Photograph of sRFA-needle and magnified image (inset) of sensing point. Relative conductance change of f) P-sensor under hydrostatic air pressure and g) T-sensor under increasing surrounding temperature. h) Change in normalized conductance of sensor under various chemical environments, including different pH solutions and a phosphate-buffered saline solution. i) Change in the relative conductance of the P-sensor over 500 cycles of cyclic hydrostatic pressure loading, and j) profile of relative conductance during the first and last four cycles. Credit: DOI: 10.1002/advs.202100725

Researchers have designed a thin polymeric sensor platform on a radiofrequency ablation needle to monitor temperature and pressure in real time. The sensors integrated onto 1.5 mm diameter needle tip have proven their efficacy during clinical tests and expect to provide a new opportunity for safer and more effective medical practices. The research was reported in *Advanced Science* as the frontispiece on August 5.

Radiofrequency ablation (RFA) is a minimally invasive surgery technique for removing tumors and treating cardiovascular disease. During a procedure, an unintended audible explosion called 'steam pop' can occur due to the increased internal steam pressure in the ablation region. This phenomenon has been cited as a cause of various negative thermal and mechanical effects on neighboring tissue. Even more, the relationship between steam pop and cancer recurrence is still being investigated.

Professor Inkyu Park said that his team's integrated sensors reliably detected the occurrence of steam pop. The sensors also monitor rapidly spreading hot steam in tissue. It is expected that the diverse properties of tissue undergoing RFA could be checked by utilizing the physical sensors integrated on the needle.

"We believe that the integrated sensors can provide useful information about a variety of medical procedures and accompanying environmental changes in the human body, and help develop more effective and safer surgical procedures," said Professor Park.

Professor Park's team built a thin film type pressure and temperature sensor stack with a thickness of less than 10 µm using a microfabrication process. For the pressure sensor, the team used contact resistance changes between metal electrodes and a carbon nanotube coated polymeric membrane. The entire sensor array was thoroughly insulated with medical tubes to minimize any exposure of the sensor materials to external tissue and maximize its biocompatibility.

During the clinical trial, the research team found that the accumulated hot steam is suddenly released during steam pops and this hot air spreads to neighboring tissue, which accelerates the ablation process. Furthermore, using in-situ ultrasound imaging and computational simulations, the research team could confirm the non-uniform temperature distribution around the RFA needle can be one of the primary reasons for the steam popping.

Professor Park explained that various physical and chemical sensors for different targets can be added to create other medical devices and industrial tools.

"This result will expand the usability and applicability of current flexible sensor technologies. We are also trying to integrate this sensor onto a 0.3mm diameter needle for in-vivo diagnosis applications and expect that this approach can be applied to other medical treatments as well as the industrial field," added Professor Park. This study was supported by the National Research Foundation of Korea.

More information: Jaeho Park et al, Real-Time Internal Steam Pop Detection during Radiofrequency Ablation with a Radiofrequency Ablation Needle Integrated with a Temperature and Pressure Sensor: Preclinical and Clinical Pilot Tests, *Advanced Science* (2021). DOI: 10.1002/advs.202100725

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