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Radio Waves Fire Up Nanotubes Embedded in Tumors, Destroying Liver Cancer

Preclinical results reported by M. D. Anderson, Rice in the journal Cancer

HOUSTON — Cancer cells treated with carbon nanotubes can be destroyed by non-invasive radio waves that heat up the nanotubes while sparing untreated tissue, a research team led by scientists at The University of Texas M. D. Anderson Cancer Center and Rice University has shown in preclinical experiments.

In a paper posted online ahead of December publication in the journal Cancer, researchers show that the technique completely destroyed liver cancer tumors in rabbits. There were no side effects noted. However, some healthy liver tissue within 2-5 millimeters of the tumors sustained heat damage due to nanotube leakage from the tumor.

"These are promising, even exciting, preclinical results in this liver cancer model," says senior author Steven Curley, M.D., professor in M. D. Anderson's Department of Surgical Oncology. "Our next step is to look at ways to more precisely target the nanotubes so they attach to, and are taken up by, cancer cells while avoiding normal tissue."

Targeting the nanotubes solely to cancer cells is the major challenge in advancing the therapy, Curley says. Research is under way to bind the nanotubes to antibodies, peptides or other agents that in turn target molecules expressed on cancer cells. To complicate matters, most such molecules also are expressed in normal tissue.

Curley estimates that a clinical trial is at least three to four years away.

Curley conducted the research at M. D. Anderson in collaboration with nanotechnology experts at Rice University and with Erie, Pennsylvania, entrepreneur John Kanzius of ThermMed LLC, who invented the experimental radiofrequency generator used in the experiments. Kanzius is a cancer survivor and former radio station owner whose insights into the potential of targeted radio waves inspired this line of research.

At Rice, the work was begun by Nobel laureate Richard Smalley, several months before his untimely death from cancer in October 2005. Smalley was the founder of Rice's Carbon Nanotechnology Laboratory and one of the world's foremost experts on carbon nanotubes. He shared the Nobel Prize for the 1985 discovery of fullerenes, the family of carbon molecules that includes nanotubes. His research in 2005 was concentrated largely on the radiofrequency cancer research project.

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Rice materials scientist professor Boris Yakobson, Ph.D., a co-author on the paper, recalled meeting with Smalley in his hospital room at M. D. Anderson five days before his death.

"He looked very ill, breathing heavily through the oxygen mask, but all he wanted to do was talk about the physics of this very phenomenon," Yakobson said. "Oblivious of his ebbing health, Rick was focused in the future. He had told Congress in 1999 that nanotechnology would help revolutionize cancer treatment, and he was a scientist wanting to know whether this technology might be one of the things that would make that possible."

In the liver cancer experiment, a solution of single-walled carbon nanotubes was injected directly into the tumors. Four treated rabbits were then exposed to two minutes of radiofrequency treatment, resulting in thermal destruction of their tumors.

Carbon nanotubes are hollow cylinders of pure carbon that measure about a billionth of a meter, or one nanometer, across.

Control group tumors that were treated only by radiofrequency exposure or only by nanotubes were undamaged.

In lab experiments, two lines of liver cancer cells and one pancreatic cancer cell line were destroyed after being incubated with nanotubes and exposed to the radiofrequency field.

"I'm humbled by the results of this research," says Kanzius. "I realize it's early in the race, but Dr. Curley and his team have moved on this carefully with utmost speed. I look forward to continuing to work with them and hopefully to watching the first person be treated with this procedure. The race isn't over but it needs to be taken to the finish line."

Radiofrequency energy fields penetrate deeply into tissue, so it would be possible to deliver heat anywhere in the body if targeted nanotubes or other nanoparticles can be delivered to cancerous cells, Curley says. Without such a target, radio waves will pass harmlessly through the body.

An invasive technique known as radio frequency ablation is used to treat some malignant tumors, the authors note. It requires insertion of needle electrodes directly into the tumors. Incomplete tumor destruction occurs in 5 to 40 percent of cases, normal tissue is damaged and complications arise in 10 percent of patients who suffer such damage. Radiofrequency ablation is limited to liver, kidney, breast, lung and bone cancers.

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