Computer-Guided Nanoparticle Therapy Destroys Tumors

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Gold nanoshells are among the most promising new nanoscale therapeutics being developed to kill tumors, acting as antennas that turn light energy into heat that cooks cancer to death. Now, a multi-institutional research team has shown that polymer-coated gold nanorods one-up their spherical counterparts, with a single dose completely destroying all tumors in a nonhuman animal model of human cancer.

Reporting its work in the journal Cancer Research, a research team headed by Sangeeta N. Bhatia, M.D., Ph.D., Massachusetts Institute of Technology, and Michael J. Sailor, Ph.D., University of California, San Diego, described its development of gold nanorods, coated with polyethylene glycol, which set a new record for the time they remain circulating in the bloodstream. This long-circulation half-life of approximately 17 hours affords the nanorods the opportunity to accumulate in tumors, thanks to the leaky blood vessels that surround malignancies. Both Dr. Bhatia and Dr. Sailor are members of the National Cancer Institute's Alliance for Nanotechnology in Cancer.

Gold nanoparticles can absorb different frequencies of light, depending on their shape. The rod-shaped particles developed for this study absorb near-infrared light, which heats the nanorods but passes harmlessly through human tissue. In the current work, tumors in mice that received an intravenous injection of nanorods plus near-infrared laser treatment disappeared within 15 days. Those mice survived for 3 months, with no evidence of recurrence, until the end of the study, whereas mice that received no treatment or only the nanorods or laser died within weeks.

During a single exposure to a near-infrared laser, the nanorods heat up to 70° C, hot enough to kill tumor cells. Additionally, heating them to a lower temperature weakens tumor cells enough to enhance the effectiveness of existing chemotherapy treatments, raising the possibility of using the nanorods as a supplement to those treatments. The nanorods also could be used to kill tumor cells left behind after surgery. The investigators note that the nanorods can be more than 1,000 times more precise than a surgeon's scalpel, so potentially they could remove residual cells the surgeon cannot get at.

Another useful characteristic of the gold nanorods is that they are very efficient at absorbing x-rays, providing a sensitivity boost to x-ray imaging methods such as computerized tomography scanning. The investigators took advantage of this property, using x-rays to create a detailed three-dimensional map of where the nanorods accumulated in the tumor-bearing animals. They then used this map to calculate the optimal irradiation protocol to maximize the tumor-killing effect and minimize damage to healthy tissue.

The nanorods' homing abilities also make them a promising tool for diagnosing tumors. After the particles are injected, they can be imaged using a technique known as Raman scattering. Any tissue that lights up, other than liver or spleen tissue, could harbor an invasive tumor. In a second paper, published in the journal Advanced Materials, the researchers showed they could enhance the nanorods' imaging abilities by adding molecules that absorb near-infrared light to the surface of the nanorods. Because of this surface-enhanced Raman scattering, very low concentrations of nanorods—only a few parts per trillion in water—can be detected.

Another advantage of the nanorods is that by coating them with different types of light-scattering molecules, they can be designed to simultaneously gather multiple types of information—not only whether there is a tumor but also whether there is a risk of it invading other tissues, whether it is a primary or secondary tumor, and where it originated.

This work, which is detailed in the paper "Computationally guided photothermal tumor therapy using long-circulating gold nanorod antennas," was supported by the NCI Alliance for Nanotechnology in Cancer, a comprehensive initiative designed to accelerate the application of nanotechnology to the prevention, diagnosis, and treatment of cancer. Investigators from the Indian Institute of Technology, Madras, also participated in this study. An abstract is available at the journal's Web site.

There is no abstract available for the second paper "SERS-coded gold nanorods as a multifunctional platform for densely multiplexed near-infrared imaging and photothermal heating."

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