Nanodiamonds take big step toward battling cancer

March 9 2011

Chemotherapy drug resistance contributes to treatment failure in more than 90 percent of metastatic cancers. Overcoming this hurdle would significantly improve cancer survival rates.

Dean Ho, an associate professor of biomedical engineering and mechanical engineering at Northwestern University, believes a tiny carbon particle called a nanodiamond may offer an effective drug delivery solution for hard-to-treat cancers.

In studies of liver and breast cancer models in vivo, Ho and a multidisciplinary team of scientists, engineers and clinicians found that a normally lethal amount of a chemotherapy drug when bound to nanodiamonds significantly reduced the size of tumors in mice. Survival rates also increased and no toxic effects on tissues and organs were observed.

This is the first work to demonstrate the significance and translational potential of nanodiamonds in the treatment of chemotherapy-resistant cancers. The results will be published March 9 in the journal *Science Translational Medicine.*

"Our results show the nanodiamond's enormous translational potential towards significantly improving the efficacy of drug-resistant cancer treatment and simultaneously improving safety," said Ho, who led the research and is corresponding author of the paper. "These are critical benefits. We chose to study these chemo-resistant cancers because they

remain one of the biggest barriers to treating cancer and improving patient survival."

Ho is with Northwestern's McCormick School of Engineering and Applied Science and is a member of the Robert H. Lurie Comprehensive Cancer Center of Northwestern University.

Nanodiamonds are carbon-based materials approximately 2 to 8 nanometers in diameter. Each nanodiamond's surface possesses functional groups that allow a wide spectrum of compounds to be attached to it, including chemotherapy agents.

The researchers took these nanodiamonds and reversibly bound the common chemotherapy drug doxorubicin to them using a scalable synthesis process, which enhances sustained drug release.

Ho and his colleagues studied mouse models with liver and breast cancers. In these resistant cancers, drugs are able to get inside the tumors but are kicked right back out because of an innate response in the liver and breast to expel these drugs.

They treated one group of animals with the doxorubicin-nanodiamond complexes and another group with the drug alone. In those treated with the nanodiamond complexes, the chemotherapeutic remained in circulation longer -- up to 10 times longer -- than those treated with the drug alone. In addition, the drug itself was retained within both types of tumors for a significantly longer period of time. Such a high retention rate means a smaller amount of the very toxic drug would need to be administered, thus reducing side effects.

The researchers also found that the drug-nanodiamond complexes had no negative effect on the white blood cell count. This is especially important for cancer treatment: if the white blood cell count drops below

a certain level, treatment is stopped due to the risk of major complications.

"Nanodiamonds have excellent biocompatibility, and the process of formulating nanodiamond-drug complexes is very inexpensive," said Edward K. Chow, a postdoctoral fellow with the G.W. Hooper Foundation and the University of California, San Francisco, and first author of the paper. "Nanodiamonds possess numerous hallmarks of an ideal drug delivery system and are promising platforms for advancing cancer therapy."

More information: The paper is titled "Nanodiamond Therapeutic Delivery Agents Mediate Enhanced Chemoresistant Tumor Treatment."

Provided by Northwestern University

Citation: Nanodiamonds take big step toward battling cancer (2011, March 9) retrieved 26 April 2024 from https://phys.org/news/2011-03-nanodiamonds-big-cancer.html

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