Cancer Drug Linked to Quantum Dots Increases Drug Uptake, Reduces Inflammatory Response, UB Researchers Show

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BUFFALO, N.Y. -- Researchers at the University at Buffalo have developed a novel technology using quantum dots that is expected to have major implications for research and treatment of tuberculosis, as well as other inflammatory lung diseases.

A paper appearing online in Nanomedicine: Nanotechnology, Biology and Medicine as an article-in-press describes specific delivery of a chemotherapeutic drug to specific cells in the lung, particularly the alveolar white cell, without causing acute inflammation.

Quantum dots are tiny semiconductor particles generally no larger than 10 nanometers that can be made to fluoresce in different colors depending on their size. Scientists are interested in quantum dots because they are a superb carrier and last much longer than conventional dyes used to tag molecules, which usually stop emitting light in seconds.

"The ability to target specific cells in the lung without exposing surrounding cells and tissue or distant organs to the detrimental effects of drugs is an exciting avenue to explore," says Krishnan V. Chakravarthy, PhD, a research fellow in the UB School of Medicine and Biomedical Sciences joint MD/PhD program and lead author on the paper.

"We have been able to prove this in both cultured cells and in animals," he continues. "The technology is still in its infancy, but being able to conduct these experiments in the whole animal makes it more promising as a clinical application. The long-term goal would be to do targeted drug delivery through aerosolized techniques, making it suitable for clinical use."

Researchers in UB's Institute of Lasers, Photonics and Biophotonics have made major advancements in the use of quantum dots, sometimes called artificial atoms, to build new devices for biological and environmental sensing.

In this research, quantum dots were linked with doxorubicin, an anti-cancer chemotherapy drug, to target specific lung cells, known as alveolar macrophages (aMØ) which play a critical role in the pathogenesis of various inflammatory lung injuries.

"The aMØ is the sentinel cell involved in directing the host innate and adaptive immune responses involved in infectious and non-infectious lung diseases such as COPD," notes Chakravarthy. "The aMØ's central role in response to environmental influences makes these cells an ideal candidate for targeted drug delivery to modulate the immune/inflammatory response."

To test the ability of linked quantum dot-doxorubicin (QD-DOX) to decrease lung inflammation, the researchers delivered QD-DOX or doxorubicin alone to rats and mice and assessed the damage to the lung. Doxorubicin, a frequently used cancer drug, is known to cause a variety of damaging immune responses in cancer patients.

Results showed that QD-DOX increased uptake of the drug compared with doxorubicin alone, and did not cause as significant a pro-inflammatory response as doxorubicin alone. The researchers also demonstrated that the drug is released from the QD-DOX formulation once it is delivered into the targeted cell and still retains its bioactivity.

"Based on these results, we believe that linking quantum dots with therapeutic drugs may have tremendous potential for diagnosis and treatment of lung injury compared to other nanoparticle formulations, and should be further developed for lung pharmacotherapy applications," says Chakravarthy.

Additional authors on the paper, all from UB, are Bruce A. Davidson, PhD; Jadwiga D. Helsinki; Hong Ding, PhD; Wing-Cheung Law; Ken-Tye Yong, PhD; Paras N. Prasad, PhD; and Paul Knight, MD, PhD.

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