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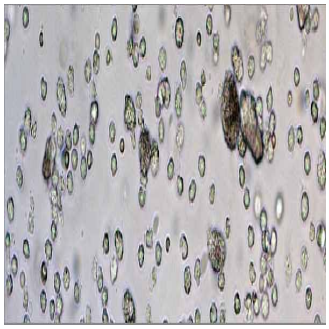
Injectable 3D Vaccines Could Fight Cancer, Infectious Diseases



According to a new study, a non-surgical injection of programmable biomaterial that spontaneously assembles in vivo into a 3D structure could fight and even help prevent cancer as well as infectious diseases such as HIV. The study, conducted by researchers at the Wyss Institute for Biologically Inspired Engineering and Harvard's School of Engineering and Applied Sciences (SEAS), is published in *Nature Biotechnology*.

What makes cancer so deadly is that it can evade attack from the body's immune system, allowing tumours to flourish and spread. Now scientists can try to induce the immune system, known as immunotherapy, to go into attack mode to fight cancer and to build long lasting immune resistance to cancer cells.

"We can create 3D structures using minimally invasive delivery to enrich and activate a host's immune cells to target and attack harmful cells in vivo," said the study's senior author David Mooney, PhD, a Wyss Institute Core Faculty Member and the Robert P. Pinkas Family Professor of Bioengineering at Harvard SEAS.

Tiny biodegradable rod-like structures made from silica, known as mesoporous silica rods (MSRs), can be loaded with biological and chemical drug materials and then delivered by needle just underneath the skin. The rods spontaneously assemble at the vaccination site to form a three-dimensional scaffold, like pouring a box of matchsticks into a pile on a table, the researchers explained. The porous spaces in the stack of MSRs are large enough to recruit and fill up with dendritic cells, which are "surveillance" cells that monitor the body and trigger an immune response when a harmful presence is detected.

Once the 3D scaffold has recruited dendritic cells from the body, the drugs contained in the MSRs are released, which trips their "surveillance" trigger and initiates an immune response. The activated dendritic cells leave the scaffold and travel to the lymph nodes, where they raise alarm and direct the body's immune system to attack specific cells, such as cancerous cells. At the site of the injection, the MSRs biodegrade and dissolve naturally within a few months, the research team noted.

Synthesised in the lab, the MSRs are built with small holes (nanopores) inside. "Nano-sized mesoporous silica particles have already been established as useful for manipulating individual cells from the inside, but this is the first time that larger particles, in the micron-sized range, are used to create a 3D in vivo scaffold that can recruit and attract tens of millions of immune cells," said co-lead author Jaeyun Kim, PhD, an Assistant Professor of Chemical Engineering at Sungkyunkwan University and a former Wyss Institute Postdoctoral Fellow.

The nanopores can be filled with specific cytokines, large protein antigens, oligonucleotides, or any variety of drugs of interest to allow a vast number of possible combinations to treat a range of infections.

"Although right now we are focusing on developing a cancer vaccine, in the future we could be able to manipulate which type of dendritic cells or other types of immune cells are recruited to the 3D scaffold by using different kinds of cytokines released from the MSRs," co-lead author Aileen Li noted.

"By tuning the surface properties and pore size of the MSRs, and therefore controlling the introduction and release of various proteins and drugs, we can manipulate the immune system to treat multiple diseases," added Li, a graduate student pursuing her PhD in bioengineering at Harvard SEAS.

While the 3D vaccine has only been tested in mice, the researchers said that it is highly effective. An experiment showed that the injectable 3D scaffold recruited and attracted millions of dendritic cells in a host mouse, before dispersing the cells to the lymph nodes and triggering a powerful immune response.

Since the vaccine works by triggering an immune response, the method could even be used preventatively by building the body's immune resistance prior to infection.

The vaccines are easily and rapidly manufactured so that they could potentially be widely available very quickly in the face of an emerging infectious disease. "We anticipate 3D vaccines could be broadly useful for many settings, and their injectable nature would also make them easy to administer both inside and outside a clinic," Mooney said.

As Wyss Institute Founding Director Donald Ingber, MD, PhD, pointed out: "Injectable immunotherapies that use programmable biomaterials as a powerful vehicle to deliver targeted treatment and preventative care could help fight a whole range of deadly infections, including common worldwide killers like HIV and Ebola, as well as cancer."

Source: EurekAlert.org
Image Credit: Wyss Institute at Harvard University

Published on : Mon, 15 Dec 2014