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Vaccine Implant Could Eliminate Painful Booster Shots

A new remote-controlled vaccine delivery system could eliminate the need for follow-up booster shots. The system uses a single shot to deliver a small, squishy, vaccine-containing hydrogel sphere to a spot beneath the skin. Then, swallowing a pill releases additional doses of vaccine.

These injectable pea-sized hydrogel capsules (left) contain a vaccine that can be activated later by swallowing a pill (schematic, right). RAPHAEL GUBELI/GUBELI ET AL., ADVANCED FUNCTIONAL MATERIALS [2013]

IF YOU'VE EVER experienced the three-part hepatitis B vaccine series, or – heaven forbid – the multi-jab rabies course, you know the joy of being turned into a human pincushion. Even if you don't mind needles, each booster shot means another trip to the doctor's office.

But now scientists have come up with a remote-controlled vaccine delivery system that eliminates the need for follow-up injections. The new system uses a single shot to deliver a small, squishy, vaccine-containing hydrogel sphere to a spot

beneath the skin. Then, instead of booster shots, swallowing a pill releases additional doses of vaccine. So in theory, instead of going back to the clinic for more syringe action, you could simply set a reminder on your phone and pop a pill.

The system has only been tested in mice, but so far the results are promising.

Many vaccines require multiple shots because it takes time and repeated exposures to train the immune system to recognize and respond effectively to pathogens. In developing countries, repeated vaccination shots aren't always possible. And even in countries like the U.S., where dozens of injections are recommended by the time a toddler is two years old, people can fail to follow up on booster shots.

"Our idea was to develop a material that simplifies vaccinations by reducing the number of injections," said biochemist Raphael Gubeli, now at Switzerland's Ecole Polytechnique Federale de Lausanne. Gubeli and colleagues, including Wilfried Weber of the University of Freiburg in Germany, reported the system Nov. 15 in *Advanced Functional Materials*.

The material is a hydrogel, a type of water-based polymer that is biocompatible and can change shape in response to things like temperature, pH, or salt concentrations. The other part of the system – the trigger – is fluorescein, a compound that's already been approved for use in humans.

In the most recent study, the team made a hydrogel mesh from fluorescein-responsive polymers. They locked human papillomavirus (a cancer-causing pathogen) vaccine particles inside the squishy cage, then they implanted the tiny, hydrogel spheres in mice.

"It's small, and it's very soft material. It's like a gum," Gubeli said. "I don't think that you would really feel it."

Giving the mice a fluorescein-containing pill dissolved the mesh and released the HPV vaccine, producing an immune response comparable to mice that had been given a normal, two-shot treatment. Mice that didn't get the fluorescein displayed no immune response. "We didn't expect that it would work from the beginning, but it was quite straightforward," Gubeli said.

They've also tested a slightly different system in mice that delivers the Hepatitis B vaccine.

The remote-controlled vaccine delivery system is very innovative, says biomedical engineer Chun Wang, of the University of Minnesota. "It's the first time that these systems were demonstrated to be effective as a vaccine delivery system in mice, using a real vaccine," said Wang, who was not involved with the work. But, he cautions, "Bear in mind that mice are very different from humans."

There are many steps that need taking before the system arrives at your local clinic, and Gubeli and his colleagues are working on that. Among other things, the team still needs to optimize the concentration of fluorescein needed to trigger the release of vaccine. They're also investigating how long the injected hydrogel stays stable in tissue and trying to modify the system to deliver more than just a single booster dose.

"At the moment we are thinking about this multiple release regime," Gubeli said. "And we are also thinking about not only delivering vaccines, but also therapeutic proteins like antibodies."

Nadia is a science reporter who enjoys telling true stories about planets and animals and bugs and spiders and crazy materials and...ok, science.

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