Research team developing injectable treatment for soldiers wounded in battle

November 19 2014, by Ryan Garcia

Internal bleeding is a leading cause of death on the battlefield, but a new, injectable material developed by team of researchers from Texas A&M University and the Massachusetts Institute of Technology could buy wounded soldiers the time they need to survive by preventing blood loss from serious internal injuries.

The potentially life-saving treatment comes in the form of a biodegradable gelatin substance that has been embedded with nano-sized silicate discs that aid in coagulation. Once injected, the material locks into place at the site of the injury and rapidly decreases the time it takes for blood to clot – in some instances by a whopping 77 percent, says Akhilesh Gaharwar, assistant professor of biomedical engineering at Texas A&M and member of the research team. The team's findings are detailed in the scientific journal *ACS Nano* and supported by the U.S. Army Research Office.

Though it's still in early testing, Gaharwar envisions the biomaterial being preloaded into syringes that soldiers can carry with them into combat situations. If a soldier experiences a penetrating, incompressible injury – one where it is difficult if not impossible to apply the pressure needed to stop the bleeding – he or she can inject the material into the wound site where it will trigger a rapid coagulation and provide enough time to get to a medical facility for treatment, he says.

"The time to get to a medical facility can take a half hour to an hour, and this hour is crucial; it can decide life and death," Gaharwar says. "Our material's combination of injectability, rapid mechanical recovery, physiological stability and the ability to promote coagulation result in a hemostat for treating incompressible wounds in out-of-hospital, emergency situations," Gaharwar says.

Unlike some injectable solutions, which pose the risk of flowing to other parts of the body and forming unintended and potentially harmful clot formations, the material designed by Gaharwar and his colleagues solidifies at the site of the wound and begins promoting coagulation in the targeted area. What's more, it accomplishes this, Gaharwar explains, without the need for applied pressure, separating it from other types of wound treatments such as tourniquets, patches and sealants.

"Most of these penetrating injuries, which today are the result of explosive devices, rupture blood vessels and create internal hemorrhages through which a person is constantly losing blood," Gaharwar notes. "You can't apply pressure inside your body, so you have to have something that can quickly clot the blood without needing pressure."

In order to engineer the material, Gaharwar and his fellow researchers went about modifying a substance known as a hydrogel. Hydrogels are biodegradable materials used in a number of biomedical applications because of their compatibility with the body and its processes. By inserting two-dimensional nanoplatelets into the hydrogel, the team was able to tweak the mechanical properties of material. Essentially, they manipulated the material so that it could be injected into the body and then regain its shape once inside the body – something necessary for locking itself in place at the wound site, Gaharwar explains.

The use of two-dimensional materials, Gaharwar says, represents a new direction in biomedical engineering. Two-dimensional materials are ultrathin substances with high surface area but a thickness of a few nanometers or less. Think of a sheet of paper but on a much smaller scale. For example, a sheet of paper is 100,000 nanometers thick; Gaharwar's nanoplatelets are one nanometer thick.

Gaharwar and his colleagues employ two-dimensional, disc-shaped particles known as synthetic silicate nanoplatelets. Because of their shape, these platelets have a high surface area, he explains. The structure, composition and arrangement of the platelets result in both positive and negative charges on each particle. These charges, Gaharwar explains, cause the platelets to interact with the hydrogel in a unique way. Specifically, the interaction causes the gel to temporarily undergo a change in its viscosity when mechanical force is applied, much like ketchup being squeezed from a bottle. This change allows the hydrogel to be injected and regain its shape once inside the body, Gaharwar explains.

In addition to changing the mechanical properties of the hydrogel, these disc-shaped nanoplatelets interact with blood to promote clotting, Gaharwar says, noting that animal models have shown clot formation occurring in about one minute as opposed to five minutes without the presence of these nanoparticles. Animal model, he adds, also have demonstrated the formation of life-saving clot formations when the enhanced biomaterial was used.

"These 2D, silicate nanoparticles are unprecedented in the biomedical field, and their use promises to lead to both conceptual and therapeutic advances in the important and emerging field of tissue engineering, drug delivery, cancer therapies and immune engineering," Gaharwar says.

Encouraged by its results, the team plans on further enhancing the biomaterial so that it can initiate regeneration of damaged tissues through the formation of new blood vessels, Gaharwar says. The result, he adds, could be a two-pronged wound treatment – one that not only aids in damage control but also assists the body's natural healing process.

More information: "Shear-Thinning Nanocomposite Hydrogels for the Treatment of Hemorrhage" *ACS Nano*, 2014, 8 (10), pp 9833–9842 DOI: 10.1021/nn503719n

Provided by Texas A&M University