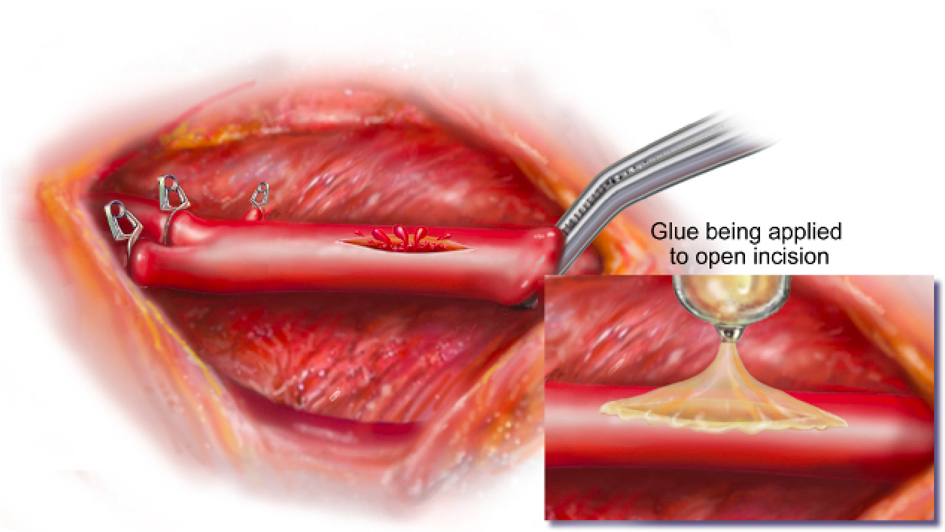
Next Generation: Strong Surgical Glue on Demand

Researchers create a nature-inspired nontoxic polymer that, when activated by light, becomes tacky and can seal ruptured, torn blood vessels and patch up holes in a pig heart.

By Anna Azvolinsky | January 8, 2014



The application of glue to a vessel defect.
RANDAL MCKENZIE (MCKENZIE ILLUSTRATIONS)

The material: Inspired by the gooey secretions made by slugs, snails, and worms, and realizing an opportunity to improve how blood vessels and congenital heart defects are repaired during surgery, researchers in Boston have developed and tested a new type of surgical glue. The material has all the right properties: it sticks well to wet tissue, repels blood and water, and is strong enough to bind major blood vessels even when under the pressure of flowing blood. The team, led by Jeffrey Karp, a bioengineer at the Brigham and Women's Hospital in Boston, Massachusetts, and Boston Children's Hospital cardiac surgeon Pedro del Nido, has so far shown that the glue can seal the carotid artery and stick to the heart wall during surgery in pigs.

"We tested the adhesive in probably the most demanding and dynamic environment in the body—the heart—and found that it works. This is a very high bar," said del Nido. "Something like this could revolutionize the way surgery is done, especially on the delicate tissue of newborns and children."

What's new: Contractions of the heart and constant blood flow make reconnecting blood vessels, attaching devices, and sealing holes in the heart during surgery difficult. Sutures and staples are routinely used, but are not elastic and can exert damaging pressure on tissue. Yet most currently available medical-grade superglues are toxic—triggering an inflammatory response—and buckle under the high-pressure force of blood flowing in larger vessels.

This new material "is able to resist physiologic blood pressures while maintaining some elasticity, allowing for proper function of the vessel," said Guillermo Ameer, a biomedical engineer at Northwestern University in Evanston, Illinois, who was not involved in the work.

When del Nido told Karp that better ways of sealing congenital heart defects in infants were needed, the two created a laundry list of properties of the ideal surgical glue. The material had to be elastic, biodegradable, biocompatible, and had to stick strongly to tissue under wet conditions, especially in presence of blood. Karp then dug into the toolbox of materials his lab had already developed along with collaborator Robert Langer, a chemical engineer at the Massachusetts Institute of Technology, and found that the pre-polymer poly(glycerol sebacate acrylate), or PGSA, fit all of the criteria except that it was only partially adhesive.

So the researchers modified PGSA so that it would attach well to tissue and imparted the material with on-demand adhesiveness. The resulting glue contains a chemical that when activated by ultraviolet light creates free radicals that lock the polymer in place, but allows the material to remain elastic.

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While light-activated materials are not novel, “the ability of this cured polymer to function under the difficult circumstances of a torn or ruptured vessel makes this material potentially unique,” said Ameer.

The viscous secretions made by insects and spiders that are slow moving and are, therefore, not easily washed away from wet surfaces inspired the new glue. These bug-made materials often contain hydrophobic agents that repel water, just like the new adhesive.

“[The authors] have really done a great job in targeting the barriers for clinical translation,” said Jennifer Elisseeff, a biomedical engineer at Johns Hopkins University in Baltimore, Maryland, who was not involved in the work. “Being able to work easily in a wet environment is a big deal and the flexibility [of the material] on a beating heart is really incredible.”

The importance: The light-activated glue could allow surgeons to perform minimally invasive surgeries, making healing times faster and decreasing the risk of infections.

Karp sees the adhesive supplementing, and perhaps—at least for some applications—eventually replacing sutures and staples, which do not provide a tight seal and can leak, particularly in digestive tract surgeries. The adhesive may also prevent the need for subsequent surgery in cases where sutures or staples fail, said Karp.

Another application, which the team is working on, is using the glue as a controlled-release drug delivery system.

Needs improvement: “What we have shown so far is a proof of principle and a potential for use in the clinic,” said del Nido.

Long-term data on biocompatibility, degradability, and function are needed before this material makes its way onto the operating table, said Ameer. “The safety and durability of this approach will be critical to its adoption.”

The surgical glue will soon be tested as an agent to seal the holes created by sutures during cardiac surgery. “This is the first and safest place to begin to test the glue in patients because the adhesive will not be holding the vessels together,” said del Nido. The next step would be trials using the adhesive to bring vessels together or close holes in the heart without the presence of sutures.

N. Lang et al. “A blood-resistant surgical glue for minimally invasive repair of vessels and heart defects” *Science Translational Medicine*, 10.1126/scitranslmed.3006557, 2014.

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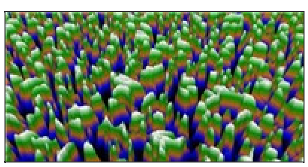

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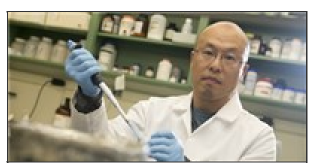

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