Medical students invent foam tool to treat battlefield wounds

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Polyurethane foam, long used in products such as bedding, furniture and insulation to make people more comfortable, someday also may save lives.

Eight Johns Hopkins University biomedical engineering students have devised a tool that may stop profuse bleeding by injecting the foam into those wounded on the battlefield.

As a class project, the students chose to tackle the problem of hemorrhaging, the top cause of death for service members in war. Existing devices - tourniquets and medicated bandages - can be unusable or ineffective in wounds to the neck or where limbs meet the torso.

"The problem is that damage from bullets and bone fragments deep inside a junctional wound is not always visible from outside the body, and a regular clotting agent may not be able to reach the origin of the bleeding," said Sydney Rooney, the student team leader and a recent Hopkins graduate.

The foam could stop the bleeding long enough to get the patient to a surgeon, Rooney said.

The technique is far from being approved by the government for use, but military and Hopkins trauma physicians say the idea has promise.

The tool is about the size of a whiteboard marker and holds two liquid

chemicals that make foam when mixed. Ideally, when the foam is plunged into a wound, it quickly hardens and stops the bleeding.

It's designed to be stable up to a temperature of 100 degrees, portable and simple to use. If it didn't have those qualities, "our target audience wouldn't use it," said Rooney, a 21-year-old who just began medical school at Vanderbilt School of Medicine in Nashville, Tenn.

During the past year and a half, the students experimented with gel to mimic human tissue and rods filled with water to take the place of blood vessels. They damaged the rods and injected the foam to stop the fluid loss. It hardened and applied pressure to the cavity walls, as planned.

Dr. Walter Franz, an Army Reserve colonel who has led "forward surgical teams" in Iraq and Afghanistan, said medical providers have developed the best methods to save lives on the battlefield over time.

Typically, a medic provides what lifesaving care he can on the battlefield, applying gauze and tourniquets to heavily bleeding wounds. Then the doctors and nurses of the forward surgical team patch the wounds, often in a tent close to the war zone, ahead of full-scale surgical fixes in a trauma hospital farther away.

There is an urgent need for new tools for the medics, said Franz, a family physician at the Mayo Clinic in Minnesota and former commander of the Army Medical Corps 945th Forward Surgical Team.

Mayo works to bring best practices from the battlefield to front-line trauma teams in the United States. Franz said the emergency medical technicians who work out of ambulances and helicopters usually are closer to trauma hospitals but also could benefit from such a tool.

"There is some bleeding we can't see and can't get a tourniquet around

it," he said. "We need a product we can pull out of a bag, which is self-contained and simple. ... I'd say to the Hopkins students, 'Keep working on it.'"

Still, he and other doctors had questions about the foam. How easy would it be for a nonsurgeon to place the foam in the right place, avoiding organs and healthy vessels? How easy would it be for doctors to remove the foam during surgery? Could it generate heat or have a chemical reaction inside the body? Would it irritate bodily tissue? Could it be toxic if left in too long? Is it stable at 30,000 feet in a helicopter used for transport over mountains in cold air?

Those may be high hurdles to overcome, said Dr. Jeffrey A. Bailey, an Air Force colonel and trauma surgeon who works in the military health system in San Antonio, Tex., as the joint trauma system director. The system makes recommendations on using new devices.

He said the foam tool would need U.S. Food and Drug Administration approval. Then the military would need to evaluate its effectiveness on the battlefield, develop guidelines and training. Even then, officials would need to constantly evaluate its effectiveness.

"We'd need to do this in a ditch or a Humvee. It's a whole different world on the battlefield," he said. "But it offers some hope and real potential."

Because many of the students have graduated from Hopkins or moved on to other classes, the continued development and testing of the device falls to doctors who sponsored the class project at All Children's Hospital in St. Petersburg, Fla., part of the Johns Hopkins Medicine system and a training site for medics in the Green Berets, Navy SEALS, Army Rangers and Marine Special Forces.

That includes Dr. Paul D. Danielson, a colonel in the Army Reserve and a pediatric trauma surgeon at All Children's. Danielson also served in a forward surgical team in Iraq and Afghanistan.

He said he's been frustrated by difficulty of controlling bleeding, which has often killed wounded service members before they reached help. Attempts to stop bleeding from junctional wounds using balloons and beads have failed. One clotting agent called Factor VII had mixed long-term results and was abandoned.

The students did some testing on the foam to rule out problems associated with temperature, user skills and biocompatibility. Now the doctors are focusing on making sure there is sufficient foam to clog a wound and that it hardens within 10 seconds. Doctors brought in a chemical engineer to work on the formula.

Once a balance is achieved, Danielson said, the doctors will find a manufacturer to make the plastic device. Eventually, to ensure safety and efficacy, they will begin testing on live tissue, animal and then human, perhaps in an emergency or operating room.

Danielson said he figures it will take about a year to know if the device is viable.

"All these problems are much better problems to have than how to notify the next of kin when someone dies," he said. "We can't put a surgeon on the battlefield to treat the wounded. We need to keep them alive long enough to get to us."

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