Traumatic hemorrhaging is the leading cause of death on the battlefield, and the fifth leading cause of death in the U.S. \([1, 2]\). In contrast to lacerations and extremity injuries, deep abdominal wounds do not readily clot, are often incompressible, and cannot be sealed with tourniquets, bandages, or tissue adhesives. These injuries require prompt surgical intervention to mitigate hemorrhaging and reduce the risk of morbidity caused by exsanguination \([3]\). Unfortunately, injured warfighters often have limited access to immediate surgical attention, and uncontrollable blood loss while in transit to a trauma center could potentially prove fatal \([3, 4]\).

The Wound Stasis Systems Program

To address this problem, the Defense Advanced Research Projects Agency (DARPA) launched the Wound Stasis Systems (WSS) program in 2010. WSS was created to facilitate the development of novel biostasis treatment strategies to improve the survivability of traumatic injuries during medical transport \([5]\). One of the program’s primary goals was to identify a suitable material that could be safely applied to the abdominal cavity, bind damaged tissue, and conform to the intricate structures of internal organs. These efforts were highly successful, and in 2013, researchers disclosed the development of an expandable foam with unique hemostatic properties to help advance DARPA’s WSS program \([6]\).

Expandable Foams

The expandable foam developed for DARPA’s WSS program consists of two polyurethane precursors that are delivered into the abdominal cavity via a pneumatically driven mixing gun \([6]\). The precursors rapidly polymerize on contact with air and dramatically expand to several times their initial volume to produce a rigid matrix that molds around vital organs. The foam stays in place for several hours and is removed from the abdominal cavity when the patient arrives on the operating table. This process is illustrated in Figure 1.

Preliminary experiments quantified the survival rates of severe liver injuries of noncoagulopathic swine with and without foam treatment \([6, 7]\). In the control group \((n = 12)\) the hepatic injury was found to be 90 percent fatal in less than an hour, and 1.5 L of blood was lost in the first 10 minutes. In the foam group \((n = 15)\), 100 percent of the animals survived after one hour, and 73 percent survived after three hours \([6]\).

It’s worth noting that the expanding foam overcame many hurdles, such as hydrodynamic forces associated with bleeding, complex anatomic topography, and the extensive pooling of blood in the abdominal cavity. Based on the success of these experiments, the clinical implications of expandable foams became immediately obvious, and the project transitioned to the U.S Army in 2015 for further development.

By: Kyle E. Giesler, John M. Saindon, & Trenton C. Elliott

March 2019

Figure 1. Overview of how ResQFoam™ expandable foam interacts with the body (Source: FDA)
Subsequent studies were initiated to design a portable delivery device and assess the foam’s performance in various environments pertinent to military personnel. It was found that the foaming reaction occurred over a relatively broad temperature range (50-122 degrees Fahrenheit), with no significant difference in performance [8].

Additionally, the foam did not produce organ dysfunction or toxicity in swine at either 28 or 90 days (the length of the study) after removal [9].

In collaboration with the U.S. Army, Arsenal Medical branded the technology as ResQFoam™ and initiated clinical trials in December 2018. The trials will evaluate efficacy and safety in human subjects (clinical trial number NCT02880163). Results from this study are eagerly anticipated.

In conclusion, uncontrollable blood loss poses a significant threat to injured warfighters on the battlefield. Expandable foam may significantly increase survival time for injured soldiers who require immediate surgery. If proven efficacious, this technology has the potential to revolutionize trauma care in both civilian and military sectors.

**REFERENCES**


BIOGRAPHIES

Kyle E. Giesler, Ph.D.
Postdoctoral Scholar, University of California, Berkeley

Kyle E. Giesler is a postdoctoral scholar at the University of California, Berkeley investigating non-viral delivery strategies for CRISPR/Cas9. He received his Ph.D. in medicinal chemistry from Emory University under the tutelage of Dennis Liotta. At Emory, he designed novel small molecules for the treatment of HIV and other chronic viral infections. From 2015 to 2017, he interned with the former Senior Vice President and Chief Patent Counsel at GlaxoSmithKline, Sherry Knowles. His research interests include drug delivery and high-risk drug discovery ventures to develop cutting-edge therapies for the treatment of human disease.

John M. Saindon, Ph.D.
Senior Health Security & CBRNE/WMD Advisor

John M. Saindon is a senior medical and CBRN/WMD advisor with over 15 years of domestic and international experiences. He received his Ph.D. and a second doctorate degree (DrHSc) in the Health Sciences from Nova Southeastern University. He also has a clinical laboratory specialization in medical technology from George Washington University. Saindon has served in multiple health security and CBRNE/WMD non-proliferation roles while deployed to Africa, Asia, and the Middle East. His research interests are in health security, emerging medical therapies on and off the battlefield, CBRN preparedness, and WMD non-proliferation.

Trenton C. Elliott, M.D.
Board-Certified Internist & HIV Specialist

Trenton C. Elliott is a board-certified internist. He completed his training at Harvard Medical School and the Fenway Institute and is now a practicing HIV specialist in Atlanta, Georgia. He is a Watson Fellow and conducted research in tropical diseases throughout South America, Southeast Asia, and Sub-Saharan Africa while working with international agencies to advance public health in developing countries. His clinical interests include virology, infectious diseases, public health, and general internal medicine.

ABOUT THIS PUBLICATION:

All information regarding non-federal, third party entities posted on the HDIAC website shall be considered informational, aimed to advance the Department of Defense Information Analysis Center (DoDIAC) objective of providing knowledge to the U.S. Government, academia, and private industry. Through these postings, HDIAC's goal is to provide awareness of opportunities to interact and collaborate. The presence of non-federal, third party information does not constitute an endorsement by the DoD or HDIAC of any non-federal entity or event sponsored by a non-federal entity. The appearance of external hyperlinks in this publication and reference herein to any specific commercial products, processes, or services by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or HDIAC. HDIAC is a DoD sponsored IAC, with policy oversight provided by the Under Secretary of Defense for Research and Engineering (USD (R&E)), and administratively managed by the Defense Technical Information Center (DTIC). For permission and restrictions on reprinting, please contact publications@hdiac.org. Any views or opinions expressed on this website do not represent those of HDIAC, DTIC, or the DoD.