It wasn’t that long ago when the concept of the future—this time beyond time, this collection of years on the horizon somewhere—was just that, a simple concept. But as we move from Operation Iraqi Freedom (OIF) and Operation Enduring Freedom (OEF) onto a newer and more complex version of the battlefield, the future is beginning to look increasingly familiar—more and more like a direct reflection of the past.

Given that a more confined and condensed combat zone will likely be the norm for future conflicts, we can no longer afford to operate as a strictly reactive medical force, simply waiting to respond to geopolitical changes and technological advances. Instead, we must build upon what we know right now, refining our tools and tactics along the way.

This is how you stay ready. This is how you save lives. This is how you win.

With that mindset, it seems appropriate to explore the ways that we at the U.S. Army Medical Research and Materiel Command (USAMRMC) Combat Casualty Care Research Program (CCCRP) are continuing to modernize in the face of global instability and potential military intervention—all with a focus on sustainment of the modern warfighter.

BLOOD: THE BATTLEFIELD NECESSITY
Modernizing can mean looking to the past to revitalize highly effective—but often lost—treatments, and blood products offer the perfect example. During the recent “throwback” efforts to modernize (during OIF and OEF) via the use of whole blood instead of crystalloid and other synthetic products, new advances in blood technology have been greatly accelerated. Of these advancements, freeze-dried plasma (FDP) remains the most potent tool because it can be brought to the Soldier on the battlefield instead of requiring evacuation to a medical facility. The benefits of FDP—which is essentially a bloodlike substance minus the red blood cells—are many, but chiefly include its portability, its lengthy shelf life and the fact that it can be quickly reconstituted with sterile water at any time. While all special operations units deployed to war zones now carry FDP kits as a matter of protocol, approval for wider use by the U.S. Food and Drug Administration (FDA) is likely several months away. Full-throttle production is shortly behind that approval and dependent upon blood collection efforts.

Meanwhile, the FDA has been an important partner in likewise advancing cold-store platelet technology, a method in which platelets are removed from donor blood, stored at refrigerator temperature and then inserted back into the patient to aid clotting and to help minimize blood loss. Those efforts, which in 2015 resulted in a landmark extension of platelet shelf life...
BETWEEN YESTERDAY AND TOMORROW

to up to three days with full functionality (as opposed to the previous standard of up to five days at room temperature, with gradually degrading functionality), have given way to current efforts focused on extending shelf life to more than two weeks, an impossibility just a few years ago. Coupled with research into cryopreserved platelets—a process in which platelets are stored, indefinitely, at negative 80 degrees Celsius—these advances potentially make the logistical nightmare of transporting blood to far-forward areas significantly less challenging.

We have long known the benefits of basic refrigeration for food storage and biologics. CCCRP efforts effectively harness those same principles to allow transport of these vital resuscitative blood products to the point of injury—a requirement on future battlefields.

Beyond that, more immediate and off-the-shelf medical solutions like advanced topical hemostatic agents (items like coagulant-impregnated dressing and granulated powders that aid blood clotting) as well as acellular regenerative vascular grafts—which are grafting procedures that combine a patient’s own cells with a three-dimensional collagen matrix to create an actual functioning vessel—further display an advancement of military medical capabilities over those employed in recent conflicts.

BURNS: A RISING THREAT

As the U.S. military community—and the world, too, it seems—adapts to the condensed cityscapes characteristic of the future battlefield, we will probably also be forced to contend with injuries that are far different than those witnessed in OIF and OEF. Indeed, combat operations in more densely populated metropolitan areas no doubt will come with a greater burn potential than anything we saw in OIF and OEF. Electrical hazards, uncontrolled urban fires and flame propagation in confined spaces—along with the possible use of thermobaric weapons, which by design produce more heat and pressure than traditional weapons by igniting explosive vapor in the blast zone—develop into major threats to the warfighter.

As such, the ability to quickly debride—remove dead, damaged or infected tissue—burn wounds will be key in these environments. While CCCRP-affiliated researchers already have received FDA approval of a laser-based imaging process developed to determine post-burn tissue viability, work continues in other areas, including the development of a “painted-on” debridement tool, which contains enzymes that can debride non-viable tissue automatically. Further, researchers are now using skin grafts from select animal species to cover burn wounds and provide temporary stability. So-called xenografting efforts use pig and fish skin samples and are an extension of long-used allografting efforts, which use stored human skin to cover wounds.

But perhaps one of the greatest threats on the future battlefield comes from possible chemical, biological, radiological or nuclear (CBRN) agents. In 2015, for example, the Pentagon acknowledged that insurgents in Iraq used chlorine as a weapon at least two dozen times, and had included parts of old Iraqi chemical munitions in homemade roadside bombs, according to an investigation by The New York Times. While the U.S. has made significant investments in CBRN countermeasures, treating trauma under these conditions remains difficult. Given

IMPROVING BATTLEFIELD OUTCOMES

Critical skills operators with U.S. Marine Corps Forces Special Operations Command simulate administering FDP to a role-playing casualty during an exercise at Camp Shelby Joint Force Training Center, Mississippi, in May 2017. All U.S. special operations forces now deploy to war zones with FDP, a crucial addition to first-aid kits that can prevent badly wounded troops from bleeding to death on the battlefield. U.S. forces used FDP in World War II, but concerns about hepatitis transmission led to its abandonment in the U.S. (U.S. Marine Corps photo by Sgt. Salvador R. Moreno, Marine Corps Forces Special Operations Command)
that treating contaminated casualties on the battlefield is exponentially more difficult than treating those injured via more common means, caring for the contaminated patient will be integral to maintaining health and resilience in future conflicts. To that end, the development and continued modernization of the Chemical Patient-Protective Wrap—or “chem wrap” for short—will be key.

Essentially a sealed bag with an attached air filter used for transporting a noncontaminated casualty through a contaminated environment, chem wrap was initially earmarked for development back in the 1980s. DOD later manufactured thousands of wraps in the early 1990s before they inevitably exceeded their life cycle later that same decade. Since then, however, the U.S. Army Medical Materiel Development Activity (USAMMDA) has teamed with a variety of other federal agencies to update and improve the material used for both the chem wrap’s main body and the seams used to hold the structure together. Recently, USAMMDA seeded $8 million to a production team at Pine Bluff Arsenal, Arkansas, to produce a stockpile of chem wraps, all of which can be made available for immediate use if required.

BURGEONING TECHNOLOGIES: THE FUTURE, REALIZED

Given a little more time, it’s likely that additional updated and advanced technologies will be making their debuts in far-forward areas as well. Chief among these technologies is the Extra Corporeal Life Support (ECLS) tool, which is already in use. Researchers are attempting to make the ECLS both much
smaller and more rugged to more closely fit the military’s vision for coming conflicts. The desire to develop these lighter, leaner capabilities comes from the need to support forward surgical teams in providing life-sustaining care to casualties for up to 72 hours.

In practice, the ECLS can be used by surgical teams to support lung function and to operate as a vital organ substitute as well—specifically for kidney and liver function—in casualties with severe injuries. Despite their promise, current iterations of the ECLS are heavy, bulky and extremely difficult to transport effectively. However, efforts are underway to reduce the size of the machine from something currently resembling a tall filing cabinet to one resembling a small, hand-portable generator. Further, researchers are attempting to minimize the number of medical staffers required to physically operate the machine—currently five or six people—with the ultimate goal being development of an automated closed-loop organ support system.

And yet, of all these fast-emerging products, it is the development of autonomous and unmanned capabilities that captures the imagination and perhaps holds the most promise. Such technologies facilitate the synergy of the overall combat effort and allow for the kind of hand-in-glove communication critical for resupply efforts and other maneuvers that ultimately support the warfighter. Imagine, for example, the development and deployment of military-grade drones charged with carrying blood to far-forward areas. Such technology would allow for the transport of lifesaving capabilities without the potential human cost of transport. Further still, the greatest and most immediate benefit of such technology may be in delivering damage control and resuscitation technologies to the combat service member at the point of injury.

To that end, and as an example, the Defense Advanced Research Projects Agency (DARPA) continues work on the Aerial Reconfigurable Embedded System (ARES), which has been under development since 2013 and is essentially a massive unmanned drone designed to carry a slew of different mission modules. Able to transport up to 3,000 pounds of supplies, the ARES could make a sizable impact in medical delivery and resupply efforts.

Here also the concept of automated vascular access comes into play. Researchers are developing miniaturized robotic units that could potentially be strapped to an injured warfighter’s leg and then—using ultrasound—automatically identify and access the correct vessel in a casualty’s leg to supply fluids or deliver medication. Automating relatively simple but time-consuming medical tasks like this could save many more lives on the battlefield than before, enabling greater resilience and more fully realizing the sustainability of a smaller, leaner forward unit. Such technology is likely between one and three years away.

**CONCLUSION**

While no future can ever be fully and correctly forecast, we believe the path that CCCRP is charting right now—using the aforementioned technologies and others, too—reveals the blueprint by which to operate. It is a blueprint centered on trauma-based psychological demands, warfighter requirements, technology and forward-leaning excellence in scientific research. It’s how we must compete in a time when the future battlefield may not be as far away as
we think—and certainly not as far away as the words might lead you to believe. These technologies, tools and methods are indeed designed to shake up the system, because projections of coming combat realities require just such an effort.

For more information on USAMRMC, go to [http://mrmc.amedd.army.mil](http://mrmc.amedd.army.mil) or contact Chelsea Bauckman, USAMRMC deputy public affairs officer, at chelsea.b.bauckman.civ@mail.mil. For more information on the CCCRP, go to [https://ccc.amedd.army.mil/Pages/default.aspx](https://ccc.amedd.army.mil/Pages/default.aspx).

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