

Putting Medical Boots on the Ground: Lessons from the War in Ukraine and Applications for Future Conflict with Near Peer Adversaries

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Abstract

In the past 20 years of the Global War on Terror (GWOT), the United States has seen substantial improvements in its system of medical delivery in combat. However, throughout that conflict, enemy forces did not have parity with the weaponry, capability, nor personnel of the United States and Allied forces. War against countries like China and Russia, who are considered near-peer adversaries in terms of capabilities, will challenge battlefield medical care in many different ways. This paper reviews the experience of a medical team, Global Surgical and Medical Support Group (GSMSG), that has been providing assistance, training, medical support, and surgical support to Ukraine since the Russian invasion began in February 2022. The team has extensive experience in medicine, surgery, austere environments, conflict zones, and building partner nation capacities. This paper compares and contrasts the healthcare systems of this war against the systems utilized during the GWOT. The lessons learned here could help the United States anticipate challenges and successfully plan for the provision of medical care in a future conflict against an adversary with capabilities close to its own.

Keywords: Ukraine, War, Trauma, Military Medicine, Medical Evacuation, Tactical Medicine

Abbreviations:

ACS, American College of Surgeons

DCR, damage control resuscitation

DCS, damage control surgery

GSMSG, Global Surgical and Medical Support Group

GWOT, Global War on Terror

IED, improvised explosive device

MEDEVAC, Medical Evacuation

NGO, non-government organization

NPA, near peer adversary

TBI, traumatic brain injury

UKRSOF, Ukrainian Special Operations Forces

Introduction

On February 24, 2022, Russia invaded Ukraine in what it called a “special military operation.” The Global Surgical and Medical Support Group (GSMSG), a non-government organization (NGO) that provides medical care and training in conflict zones, mobilized the first U.S. surgical team into Ukraine, arriving there on March 5, 2022. For the past 12 months, GSMSG has worked alongside Ukrainian forces and healthcare providers.

The conflict in Ukraine represents a unique opportunity for the United States to prepare for future potential conflicts with near-peer adversaries (NPAs)—adversarial nations with equivalent military force. Despite poor performance in smaller battles and significant losses, Russian forces remain in Ukraine, and the war continues. Russia generally has been considered an NPA to the United States, as it has a military with similar capabilities. The current threat from NPAs, such as China or Russia, is at its highest level since the Cold War Era (1). For over 20 years during the Global War on Terror (GWOT) in Iraq and Afghanistan, U.S. military forces and their medical corps were engaged in a conflict against insurgent or terrorist organizations who utilized unconventional strategies and tactics because of their vastly unequal combat capabilities. Their capability to mount offensive and defensive strategies against U.S. forces was limited. For instance, during the GWOT, the U.S.’s air, ground, and sea dominance assured relative freedom of movement for medical evacuation. The war in Ukraine, however, is a much different operating environment (Table 1). Russia has equivalent or superior combat forces to Ukraine, which limits Ukrainian mobility and evacuation (2). There are several other challenges that have been recognized, and the current conflict in Ukraine thus offers the opportunity to develop tactics, training, and a healthcare system in preparation for future conflict with an NPA.

The Global Medical and Surgical Support Group (GSMSG)

GSMSG is an NGO with extensive experience providing surgical and medical care in combat environments and austere settings around the world. GSMSG's teams of healthcare providers have experience in low resourced environments and on the battlefield. They have also responded to natural disasters like Hurricane Michael in 2018 and the COVID-19 pandemic in New York City in 2020. GSMSG also has personnel with extensive military experience, including a significant number of veterans from the U.S. Special Operations community. (Table 2).

GSMSG initially mobilized a 10-person team with combat surgery capability that entered Ukraine nine days after Russia invaded. Their mission was to: 1) provide training in combat casualty care for any interested and capable Ukrainian citizen, 2) provide combat trauma care training and surgical support for the civilian Ukrainian medical system, and 3) provide combat care training for the Ukrainian military personnel and military physicians. GSMSG rotated additional teams of surgeons with expertise in trauma, surgical critical care, burn, plastics, orthopedics, vascular, and neurosurgery. With the cooperation of the Ukrainian Ministry of Defense and Ministry of Health, GSMSG also formed a partnership with the physicians of the Ukrainian Special Operations Forces (UKRSOF), who have provided damage control surgery (DCS) as close as 0.5 kilometers from active combat with Russian forces. Since arriving in Ukraine, GSMSG team members have trained over 20,000 Ukrainian civilians and military service members. They have also provided surgical support to over 300 patients, some located as close as 10 kilometers from the frontline (Table 3 and Table 4).

The Global War on Terror versus Conflict with an NPA

GWOT: The Threat

During the GWOT, U.S. and allied forces' injuries were generally from small caliber firearms, improvised explosive devices (IEDs), and indirect fire from short-range mortars and rockets (3). There were an estimated 7,076 U.S. deaths and 53,337 U.S. wounded over the course of those 20 years (4). Explosive mechanisms of injury made up the largest portion of combat wounds in the GWOT, accounting for approximately 79% of battlefield injuries. During nearly any attack by insurgent forces, U.S. forces quickly achieved battlespace dominance and were able to evacuate casualties under the umbrella of superior ground fire or close air support (5). In general, the threats during the GWOT were limited in duration and scope (6-8). It is also well-documented that quality medical care could be rendered quickly and safely on or near the battlefield. Because of air-evacuation capabilities, patients could be brought quickly to treatment facilities. Moreover, the further medical assets were removed from the conflict, the safer they were, even if they were still in the combat theater of operations (9). Finally, damage control resuscitation (DCR) had been modified to include early use of fresh whole blood and improved protocols, which reduced the overall amount of blood product needed to save lives (10-12).

NPA Threat

Greater Lethality

Improvised explosive devices caused significant casualties in the GWOT (13). They could injure multiple personnel at once and even disable vehicles. Compared with insurgent/terrorist forces, NPAs have much heavier and longer-range weaponry, with a resultant increase in morbidity and mortality among combat casualties. While it is possible to arrange IEDs to provide successive blasts to increase their lethality, these configurations were infrequently employed in the GWOT. In Ukraine, Russian forces have used modern portable

anti-tank guided missiles with advanced dual shaped charge or thermobaric warheads, or thermobaric rocket artillery barrage fire. These thermobaric weapons cause blunt and penetrating wounds as well as massive thermal injuries (14). A recent incident utilizing this weapon claimed 12 immediate fatalities from victims who were within 20 meters of the impact point. A casualty 60 meters away from the point of impact suffered 80% total body surface area burns which proved lethal within 72 hours despite medical evacuation and resuscitation attempts.

Russian use of incendiary munitions causes significant deep burn injuries, organo-phosphate poisoning, and other toxic effects from the vapors associated with the burning substances (15). Care of burn casualties imposes a significant logistical and medical burden because of the complexity of care and the extensive resuscitation required. This underscores the need to plan for significant thermal/burn injuries in future combat.

Modern anti-tank guided missiles that have been used widely by Russia have a nearly +75% fatality rate when employed against personnel or lightly armored vehicles because they are intended for use against tanks or bunkers. U.S. military personnel encountered these weapons infrequently during the GWOT (16). They appear to be a much more frequent occurrence in this NPA conflict (17). Further, the injuries sustained have been devastating, and survival rates are significantly lower than those from non-directional blast injuries such as artillery and mortars (13). Additionally, Russian forces in this conflict have been firing nearly 60,000 artillery rounds a day. This represents a volume of fire that U.S. forces have not seen since World War II.

In Ukraine, Russian forces often used area denial munitions, such as anti-tank and anti-personnel mines. These munitions are built using standardized, consistent construction completed on a much larger scale. As such, they are more available, operationally reliable, effective, and deployable. IEDs used in the GWOT were, by definition, improvised and thus had

questionable reliability. They often comprised an array of available explosive devices and were used with much less density of devices in a given area when compared with broad NPA employment.

The safety of medical assets on the battlefield

The ability to quickly evacuate patients and the safety of responding medical teams are compromised because of better NPA weaponry. The ability of the Russian forces to strike accurately well beyond the front line with long range weapons such as cruise missiles or drones means that the threat to injured personnel only subsides once a patient is far removed from the conflict theater (Figure 1). In Ukraine, hospitals and medical facilities were targeted and hit as far west as Zhytomyr, which is approximately 400 km west of the Russian border (18) (Figure 2). Additionally, Russian missile strikes have occurred within 25 km of the Polish border with Ukraine, meaning that Russian weapons could strike medical centers in any Ukrainian city (19). In comparison, in the GWOT, the insurgent arsenal had a reach of approximately 20 km. When applied to possible future conflicts with NPAs, it is likely that the enemy's arsenal would be able to reach hundreds of kilometers from the front line. For example, the Chinese CJ-10 cruise missile is capable of carrying a 1000-lb warhead over 1500 km (20). If operation is to be performed in a forward environment, patients will need to be treated while under the threat of attack in hardened and protected facilities until the patients are removed entirely from the theater of operations.

Transfusion at the Front Line in Ukraine

Surgeons on the GSMSG teams helped incorporate whole blood use into the conflict in Ukraine in April 2022. The number of patients who arrive at a UKRSOF forward surgical team

alive and already in hemorrhagic shock is estimated at 25%. Furthermore, an additional 15-20% of alive and injured soldiers arriving at the first point of medical care needed a blood transfusion. Ukrainian surgeons operating within 0.5 km of the front line are the first to receive casualties from the battlefield. UKRSOF surgeons cite that difficulties with long-term storage pose the biggest obstacle to maintaining stores of any available blood products. Running power generators for refrigerating stored blood products at the forward surgical sites for extended periods of time could compromise security. In addition to limiting the ability to store whole blood or blood products, the lack of electrical power often prohibits thawing available frozen blood products with fluid warmers. Furthermore, supply lines to the forward surgical teams routinely come under Russian attack, impairing the ability to replenish supplies of blood products for transfusion. There are additional strategies for generating readily available whole blood for transfusion, such as the Ranger O Low Titer / Walking Blood Bank, which require a large, stable donor pool (21, 22). However, the current rate of casualties, relocation of units, or reorganization of units given the operational tempo in Ukraine precludes the ability to execute these strategies. Implementation would require broader organizational evolution of the Ukrainian military.

Greater Number of Injuries

The Ukrainian conflict has seen the use of purpose-built munitions on an industrial scale and sustained rocket and artillery barrages by Russia. This increase in firepower has translated to an increased injury burden. Statistics shared by Ukrainian physicians demonstrate that over 70% of all Ukrainian combat casualties are due to artillery and rocket barrages from Russian forces, which has resulted in significant polytrauma to multiple organ systems. By comparison, in most recent non-NPA conflicts, soldiers who sustained injuries to the thoracic and abdominal cavities

could survive if concomitant injuries to extremities and the rest of the body were limited (23). In Ukraine, Russia's weapons have led to more devastating injuries to a larger number of soldiers in any given attack. In a retrospective analysis of 100 patients treated by Ukrainian military surgeons operating within 5 kilometers of the front line, the average Injury Severity Scores exceeded 36 in victims of such barrage artillery and rocket attacks. Common mechanisms of injury include multiple high-velocity penetrating injuries, barotrauma, and blunt injuries from being thrown during the explosion, and traumatic brain injuries. A single IED or even a chain of IEDs in the GWOT generally affected fewer patients and caused less severe injury (to others besides the person who directly triggered the IED) (s) than an NPA rocket or artillery barrage, which produce dozens of explosions across a much larger area leading to simultaneous, multi-casualty situations. It is estimated that 5-10% of Ukrainian soldiers deployed to the theater of operations will be either wounded or killed in action. During the GWOT, there had been approximately 7,000 deaths and 32,000 wounded over a total of 2-3 million deployed US personnel, for a casualty incidence of 1.3-2% (24). Thus, mortality rates in this and future NPA conflicts may be 5 times greater than in the GWOT (although Ukrainian mortality rates are raw estimates based on publicly available information at this time and not adjusted for injury severity, mechanism, etc.). Overall, medical evacuation planning, prolonged field care, and other interventions planned by treating medical personnel will need to anticipate massive polytrauma, significantly more patients at a time, and the resources required for a single patient will be significantly greater.

The UKRSOF surgeons reported receiving several patients simultaneously with multiple potentially lethal injuries. Patients often require multiple emergent damage control interventions before clinicians can begin to care for the next patient. During a one-week period with sustained

incoming artillery barrage fire, a single UKRSOF surgeon treated over 200 patients, of whom 36 underwent laparotomies and 20 underwent thoracotomies. Penetrating abdominal and thoracic wounds occurred lateral to body armor plates in approximately 60% of cases and inferior to body armor in 30% of cases. An estimated 10% either had material penetrate their body armor plates or they were not wearing body armor. Traumatic penetrating injuries to the skull were nearly universally fatal and were managed expectantly.

The incidence of penetrating thoracic trauma is significantly higher in this conflict with an NPA than in the GWOT. Most soldiers in the current war in Ukraine have front and rear panel armor as well as a helmet. With incoming artillery rounds in a trench, soldiers generally face forward and cover their heads. However, this leaves the lateral aspects of the body vulnerable to injury. Use of standard center mass front and rear plate armor that protects the vital organs within “the box” may not be sufficient to save lives when ballistic material is coming from a lateral trajectory. While available U.S. body armor systems do offer more thorough lateral and abdominal protection with side armor plates and ballistic material that can protect lateral trajectory projectiles, such equipment is extremely heavy and cumbersome.

Barotrauma and Traumatic Brain Injury

Blast injuries also have barotrauma effects and can cause blunt trauma if the explosion results in the victim being thrown or large objects being launched at the victim. Consequently, traumatic brain injuries (TBIs) will likely be greater in conflicts against an NPA. During the GWOT, there was a significant incidence of TBIs sustained from single IED detonations. The concussive effects of these blasts have been well documented. Between 9% and 28% of service members experienced a TBI during the GWOT (25). In a rare modern instance of U.S. forces encountering NPA-level weaponry, the U.S. Al-Asad base in Iraq was struck by Iranian ballistic

missiles on January 8, 2020, and 109 U.S. soldiers suffered TBIs (26). In the Ukraine conflict, concussion injuries and related complaints were noted in nearly all instances of patient encounters with opposition rocket or artillery fire, though oftentimes were overshadowed by other wounds or injuries. We also know that if patients sustain successive concussions or TBIs, the long-lasting effects are significantly more devastating (27). In a combat situation against an NPA, it is likely that TBIs will be far more prevalent than what was experienced in the GWOT. Reinforcing and burying defensive positions so that personnel are not as exposed to the blast effects may help mitigate these injuries; however, medical planning should continue to be directed at prophylactic, protective, and treatment measures to combat TBIs.

Medical Evacuation (MEDEVAC)

During the GWOT, battlespace dominance by U.S. forces was usually quickly established, and threats were generally cleared before medical evacuation could occur, with the exception of rare isolated instances (28, 29). Per discussions with Ukrainian Ministry of Defense counterparts, as of this writing, there is minimal ability for the Ukrainian Air Force to fly any type of sustained air operations against Russian forces, which includes airborne MEDEVAC from front line positions or areas adjacent within the envelope of Russian anti-aircraft fire (30). Medical evacuation by ground forces also routinely comes under attack by Russian forces. The U.S. should assume that advanced, accurate, and very long-range weapon systems will be readily available to future NPAs. As such, the safety of being further away from combat will require that evacuation capabilities, whether by air, ground, or sea, may need to move hundreds of kilometers from the front line before the casualty and the MEDEVAC platform itself is actually safe from NPA fire.

This also means forward medical teams will need the capability of providing prolonged field care, more damage control resuscitation, and even multiple damage control surgeries on a larger number of patients before they can be moved away from the frontline area. UKRSOF surgeons stationed adjacent to the front line of combat often could only move patients from the point of injury to locations as close as 500m into hardened locations where a surgical team can operate and hold the patient for an extended period of time. This was occasionally done under ongoing Russian artillery and rocket fire. Future U.S. service members who are injured in combat may consequently not reach definitive care until days later and medical personnel providing care will definitely be in harm's way.

Current U.S. Department of Defense protocols and clinical practice guidelines prepare for smaller forward surgical teams to be able to operate on 2-4 surgical patients and hold 3-8 patients for 16-72 hours without resupply (31). Additionally, they should be able to pack their equipment within 1 hour in order to relocate. It is estimated that, based on UKRSOF experience in combat with Russia, such teams should be prepared to perform 10 damage control operations in 48 hours and hold up to 15 critically ill patients for the same amount of time without resupply. This is about the size of an intensive care unit in a medium-sized U.S. hospital. Expanding a forward team's capabilities would make it less mobile and more difficult to relocate. This poses an obvious paradox between the need for greater forward medical capabilities and the ability to relocate rapidly to new safer locations as needed and to maintain pace with a constantly moving front line.

Despite clearly violating international laws from the Geneva Convention, Russian forces are specifically targeting ambulances and healthcare facilities. According to the Ukraine Crisis Media Center, approximately 1,100 healthcare facilities have either been damaged or destroyed

since the beginning of the conflict (32). Forward medical facilities, like a combat support hospital, therefore, may need to be positioned entirely underground. That may mean significant investments in rapid tunneling and earth-moving type of equipment are needed, none of which currently exists in a capability that can be deployed rapidly to a battlefield. The current practice of surrounding the structures with concrete walls and earth barriers will still leave them vulnerable to vertical attack. Rapid advances in point defense systems from the existing Counter-Rocket, Artillery, Mortar (C-RAM) or the Israeli Iron Dome, will also be a necessary component of protecting critical military medical infrastructure. If waterborne evacuation is considered, future U.S. forces need to recognize that ships at sea offer very easy targets for future NPAs. A potential solution is to establish “lillypad” medical installations on any adjacent land masses, as the U.S. Pacific forces did in World War II, constructing airfields on the Marshall and Mariana Islands en route to Japan (33).

MEDEVAC operations are also more likely to be challenged by a lack of communication during conflict with an NPA. In past wars, U.S. personnel were able to communicate with MEDEVAC units to coordinate movement of injured personnel (34). The practices of opposition forces jamming the electronic spectrum used by US forces to communicate will impair these processes during future NPA conflicts. In Ukraine, responding medical personnel and receiving medical installations frequently have no advance notice as to the nature or extent of the injuries of the incoming patients from the front line for fear of Russians intercepting the communications and then attacking the location of the casualty collection point. One way for future U.S. medical teams to prepare for loss of communication will be to emphasize no-notice scenarios in training and simulation. In the civilian arena, no-notice or limited-notice scenarios may occur when patients are transported by police officers or private vehicle (35-37). All clinicians can benefit

from practicing these situations. There is reason to believe that these wartime communication obstacles would also extend to controlling and commanding medical supply chains over the entire area of operations. Through decades of conflict and prior experience in total war, such as World War II, and regional conflicts, such as Vietnam, that placed massive stress upon U.S. military medical systems, the U.S. has developed systems to properly and uniformly allocate medical assets and supplies to areas of greatest need. In the face of future NPA conflicts, the allied command-and-control hierarchy may be cut off either for operational security reasons or due to NPA disruption. This also must be addressed in a conflict against an NPA, even though it is not an entirely new concern.

Surgical Cadre

Each year, nearly 1,000 surgeons who graduate from residency training will practice general surgery in some capacity (38). There are currently 25,000 active general surgeons in the U.S., approximately 4,130 of whom are trauma surgeons (39, 40). This could serve as a sufficient pool of potentially qualified individuals who can provide competent trauma surgery services in a war with mass mobilization. Yet, even with this many qualified surgeons, it is difficult for the U.S. military to maintain a ready pool of surgeons who are well versed in damage control surgery and able to deploy to a front-line combat area at a moment's notice. Furthermore, surgical specialists, including thoracic surgeons, neurosurgeons, orthopedic surgeons, oral and maxillofacial surgeons, otolaryngologists, urologists, vascular surgeons, etc., are needed to provide comprehensive wartime care. Unfortunately, for a country like Ukraine--or any country facing opposition like Russia--it is practically impossible that they will have enough qualified surgeons on hand. It is difficult to determine the exact number of Ukrainian surgeons. Data collected by the Lancet Commission on Global Surgery in 2014 reported 87 surgeons in

Ukraine per 100,000 but did not delineate this number further by specialty or active status (41, 42). Because of the shortage, any practicing surgeon in Ukraine, regardless of training or scope of practice, may be brought combat casualty patients to manage to the best of their ability. The American College of Surgeons (ACS) created programs such as the Military Clinical Readiness Curriculum “M-Course” to teach the basics of DCS, DCR, and emergency wartime operation to help fill this gap. The ACS also collaborated with GSMSG to provide expert surgeons from the U.S. to Ukraine to work alongside host nation surgeons and to provide education and training in combat trauma-specific topics like burn surgery, plastic surgery, and even biological and chemical warfare. GSMSG’s primary goal in working with any host nation is to rapidly transfer relevant skills and knowledge to the partner force surgeons and medical professionals. As of December 2022, GSMSG has held training sessions for over 650 Ukrainian attending and resident physicians and participated in hands-on training in over 300 OR cases with Ukrainian surgeons since the start of the war.

In all, several areas of the U.S. combat medical system need to change in response to the threat of an NPA. It should be noted that in Ukraine there is currently no trauma registry similar to the one utilized by the United States Department of Defense for its wars in Iraq and Afghanistan. The data presented here is based on personal experience of GSMSG team members and first-hand reports. Establishing an effective registry with robust and reliable data capture is needed to provide proper planning and reaction to combat against an NPA as well as retrospective analysis. Furthermore, properly staffed NGOs like GSMSG can be an important asset in such conflicts, as they can provide valuable training, combat care, and experience for host nations without escalating the conflict by directly involving foreign governments or

militaries. Additionally, they can be a source of valuable information after the official involvement of the U.S. Department of Defense to help it prepare for conflict.

In summary, below are the lessons learned from the experiences of Global Surgical and Medical Support Group and partner physicians from the Ukrainian Special Operations Forces from 1 year of war against Russia in Ukraine. Considerations for future medical care in combat operations against near-peer adversaries are highlighted.

1. Injury in NPA conflict

- a. Current US military body armor will likely be insufficient against NPA arsenals with ballistic components that can hit laterally, above, or below standard issue armor plates from multiple angles due to the larger number of accurately impacting munitions.
- b. Concussive injury and TBI will be far more prevalent when facing NPA arsenals that can accurately deliver large volumes of more devastating fire.
- c. NPA arsenals will be capable of causing significant multisystem trauma to far greater numbers of US personnel.

2. Providing care for injured in NPA conflict

- a. Medical facilities are not safe areas to provide care, even if they are hundreds of kilometers from the line of ground fighting.
- b. The resources needed to adequately provide lifesaving care will be far greater than what the US has allocated for in the past.
- c. Air, ground, and sea-based medical evacuation will be practically impossible due to very long range and accurate fire capabilities of NPA arsenals; forward surgical

teams should be established in hardened structures, possibly underground, capable of withstanding direct attack by NPA munitions.

3. Preparation and training of US medical teams for NPA conflict

- a. Forward medical/surgical capabilities by US personnel will need to be able to handle more casualties simultaneously.
- b. Prolonged field care should be a routine part of the medical training curriculum, as evacuation may be delayed or impossible in an NPA conflict.
- c. In a future NPA conflict, communications may be limited or nonexistent due to jamming by the NPA or for operational security reasons, preventing advanced notice of casualty arrivals, a scenario that should be practiced regularly (no-notice casualty loads with extensive high-fidelity, situation-based training).

4. System-level preparation of the US military medical system and structure for future NPA conflict

- a. Given electronic jamming by NPA adversaries, robust and redundant command and control of medical assets should be able to be delegated further into the field.
- b. Cadres of qualified and capable surgeons need to be developed so that they are ready, able, and willing to deploy to forward locations in a future NPA conflict.
- c. Surgeons with expertise in damage control surgery and resuscitation are limited, but this gap may be filled through specialty training, either in person by groups like GSMSG or remotely through programs like the M-Course provided by the American College of Surgeons.
- d. NPAs may ignore international laws against attacking medical resources, medical evacuation platforms, and infrastructure.

- e. A database like the US Joint Trauma Registry needs to be implemented for process improvement in the war against Russia, but the US could implement its already established data collection protocol in a future NPA conflict.

Table 1: Comparison of the Global War on Terror vs Near-Peer Adversary Warfare

Variable	GWOT	NPA
Threat scope	Limited in duration, scale of attack, and weaponry used	Sustained offensive action with much broader array of weapons, in larger volume, for longer duration and further distance
Ability to quickly achieve battlespace dominance	Very fast, usually within minutes to hours	Unlikely able to achieve battlespace dominance
Effect of distance on safety of evacuation and rendering care	The further from point of injury, the safer the patient and ability to render care	No significant increase in safety until patient is entirely evacuated from the theater of operations
Use of appropriate blood transfusion for damage-control resuscitation	Well established	Unable to be achieved due to operational security considerations and disruption by opposition forces
Command and control of medical infrastructure	Well established	Unable to be achieved due to operational security considerations and disruption by opposition forces
Data collection capability for process improvement and other use	Joint Trauma Registry is well established	No central data collection currently exists for the war in Russia; a Joint Trauma Registry could easily be implemented

GWOT, global war on terror; NPA, near-peer adversary

Table 2. Composition of Global Surgical and Medical Support Group Team

GSMSG team member professional	% of total roster (n = 2,200)
Medic or licensed practical nurse *	31
Nurse	17
Nurse practitioner	8
Physician assistant	9
Emergency medicine physician	5
Anesthesiologist	6
Critical care physician	3
Other non-surgical physician	1
General surgeon	5
Orthopaedic surgeon	4
Vascular surgeon	1
Trauma surgeon (general surgery)	9
Neurosurgeon	1
Other specialty surgeon	2
Total civilian	24
Total military	76

*This includes veteran US Army combat medics, US Army special forces medics, US Navy corpsmen, US Navy special warfare medics, US Air Force pararescue, US Marine Corps special amphibious reconnaissance corpsman

GSMSG, Global Surgical and Medical Support Group

Table 3. Global Surgical and Medical Support Group Educational Activities in Ukraine, March 2022 - December 2022

Educational activity	Learners
Didactic lectures on combat trauma care, traumatic brain injury, torso trauma, orthopedic trauma, vascular trauma, etc	Ukrainian surgery/emergency medicine residents and faculty, Ukrainian surgery/emergency medicine/internal medicine/primary care/anesthesia providers
Tactical combat casualty care training	Ukrainian police departments, Ukrainian military, Ukrainian military medical providers and first responders
Stop the Bleed training	Ukrainian police officers, Ukrainian military medical providers and first responders
Infection control, sterile instrument processing, and intraoperative sterile procedures	Operating room and sterile processing personnel

Table 4. Global Surgical and Medical Support Group Surgical Case Consultations in Ukraine, March 2022 - December 2022

Specialty	Case example
Trauma	Thoracic trauma, hollow viscus injury, enterocutaneous fistula, complex skin and soft tissue wound, amputation, postoperative infection
Vascular	Limb salvage, arteriovenous fistula, pseudoaneurysm
Orthopaedics	Complex extremity fracture
Plastics	Wound debridement and flap coverage

Figure Legends

Figure 1. Linear Effect of Distance. This figure highlights the relationship of relative safety of MEDEVAC units as distance from the enemy position changes. The blue line shows the relationship in the GWOT, which highlights the rapid increase in safety with a small amount of distance from the enemy position. The red line shows the relationship in NPA conflict, which highlights that a large amount of distance from the enemy position is needed to achieve significant safety.

Figure 2: Map of Ukraine. Russian forces have struck hospitals and medical facilities in Zhytomyr, about 400 km west of the Russian-Ukrainian border. Russian missile strikes have also occurred within 25 km of the Polish-Ukrainian border, which means nearly any location within Ukraine is within Russia's reach. Image modified from Google Earth.

Appendix

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