Chapter 1
The Combat Environment: Preparation for Deployment

Keywords Deployment · Center for the Sustainment of Trauma and Readiness Skills (CSTARS) · Echelons of care · Area of operations (AOR) · Combat support hospital · Air Force theater hospital

1.1 Introduction

The environment of a deployed combat hospital brings many challenges such as artillery fire, heat, sand, dust, cold, and frequent power outages. This chapter will provide an overview of deployment preparation and battlefield challenges the military radiologist needs to know. In addition, the concepts and cases presented here should provide baseline knowledge for mass casualty/disaster preparation for any radiologist where there is an emergency room.

Trauma imaging in the combat environment parallels civilian radiology from a procedural and pathologic perspective. There are some very unique aspects of diagnostic imaging in the deployed military setting, however, including desert conditions such as heat, sand, and dust. Conditions can also include cold, mountainous, or tropical environments. In addition, patient care continues with daily power outages, combat operations, explosions, ducking in bunkers from incoming artillery fire and indirect insurgent fire, often working with cumbersome body armor. It is not unusual during continual patient care that technologists have to check for unexploded ordinance outside the department after being fired upon (daily for our tour of duty). The overarching principles of care in theater are greatly influenced by a combat environment that is very resource-limited. This is a fact that enters into every diagnostic consideration and treatment decision.

In addition to trauma and emergency care image findings seen in the US, combat unique images will be presented with representative cases in areas such as blast and high velocity missile injury as well as heroic diagnostics and therapeutics typically only seen on the battlefield. This may serve as a reference in disaster preparedness for US institutions and teaching programs in addition to university hospitals and medical centers. The information in this chapter should be generalizable to civilian

L. Folio (ed.), *Combat Radiology: Diagnostic Imaging of Blast and Ballistic Injuries*,
DOI 10.1007/978-1-4419-5854-9_1, © Springer Science+Business Media, LLC 2010

hospitals, not just trauma centers, but also the most remote [1] community hospital in America that may see the most severe trauma at any time.

Hopefully when reading this book, however, one will appreciate how we solved the problem and made up for limitations and challenges that are not traditionally encountered and would not even be considered in civilian settings, except in extreme conditions. For example, skipping the portable CXR in the ED and obtaining it on the CT scout; screening through the entire chest/abdomen/pelvis on one universal wide window in seconds to provide an overview of life threatening injuries; or compressing Gigabytes of data into megabytes (100:1 compression) and emailing mp4 videos to provide another facility a prior exam to be available. Another seemingly bold effort to answer the longitudinal medical record challenge being investigated is a personal health vault solution with uploadable compressed CT movie files online. Although the military pioneered teleradiology [2, 3] and electronic health records, increasing security requirements have severely hampered the possibility of compatible medical records and paper, e-mail, and CDs of images still being used.

1.2 Preparation for Deployment

Radiologists in the military, whether active or reservist, know that deployment is a real possibility and are often already prepared from a physical and mental perspective. Depending on where a radiologist is stationed, there are variable times and chances of being deployed. Once a radiologist is in the window of potential deployment, there are military specific requirements that need to be met. These include making sure annual immunizations are current (to include area specific immunization), annual (or bi-annual) physical fitness tests are passed, annual physical examination is completed, pistol (M9 and/or M14/M16) training is current, and that chemical, biological, and radiological warfare training is updated often prior to notification of a deployment.

1.3 Personal Effects

In addition to training for preparation for combat conditions and gathering of military specific equipment, there are personal items to strategically pack to prepare oneself for 4–6 (potentially 15) months of living in combat conditions. Figure 1.1 shows the bags I packed on my first deployment to Iraq to include military gear, personal items, a 72 h pack (the green backpack on top), and a carry-on backpack with reading material and laptop. Many experienced deployers will mark their luggage with shiny or fluorescent markers to help pick out their luggage in overseas staging airports. This helps find luggage since there are no baggage handlers; you have to find your own bags among everyone else, usually at night, outside.

Fig. 1.1 This photo was taken of me just prior to my first deployment to Iraq back in 2005. Note the two military *green bags* on the bottom; they were for chemical gear, body armor, helmet, etc. My weapon was already checked in at this point

See Fig. 1.2 of myself arriving in Balad, Iraq in a C17 after almost a week of travel on my second deployment to Iraq.

It takes weeks to receive care packages from home if something is overlooked, however, there are limited supplies sold in military stores, even in combat zones (especially where radiologists typically deploy). Military specific items necessary include helmet, body armor, weapon (M-9 or Beretta), uniforms, boots, chemical warfare gear (suit, gas mask, filters, chemical agent antidotes), self aide medical kits, etc. Mostly, everything is issued (free) to active duty and civilian contractors; however, many spend hundreds or thousands of dollars on equipment above what is issued.

Many experienced deployed military personnel use sweater/shoe organizers to maximize the small space; one must pack all their gear to have ready at a moments notice. Since there are often delays and layovers in traveling, it is imperative to have a 72 h bag prepared to live out of without digging into the four or five bags you may be traveling with. For example, we got delayed due to massive deployments and aircraft breakdown for about 100 h; so our 72 h kits (two changes of civilian clothes/shoes, shower kit) overextended themselves.

Fig. 1.2 Note the body armor and self-aide medical kit (*arrow*) everyone deploys with. We also carry our weapons, chemical warfare gear/gas mask, antidotes, and additional equipment.

Since I am also a flight surgeon and most often deploy in that capacity, I bring additional items most radiologists would not need. However, I think it is useful to have access to a short medication list that has helped me as a flight surgeon and a radiologist on deployments where I was the only doctor for several hundred deploying personnel. One must keep in mind that one travels with different groups of deployers; many times none are medical and you may be the only medical trained professional with hundreds of people that may turn to you for medical advice of all kinds. See the following reference for a list of medications that have served me well to have on hand for about eight deployments to include Bolivia, Saudi Arabia, Turkey, and the South Pole [4].

1.4 Military Training for Deployment

The moment a radiologist is officially tasked with an upcoming deployment, further training and preparation must be completed. Traditionally, most training and preparation at this point is military-specific and not necessarily related to the everyday job. As the time to depart gets closer, online and other training include hostile environment preparation, equipment gathering, instructions on how to

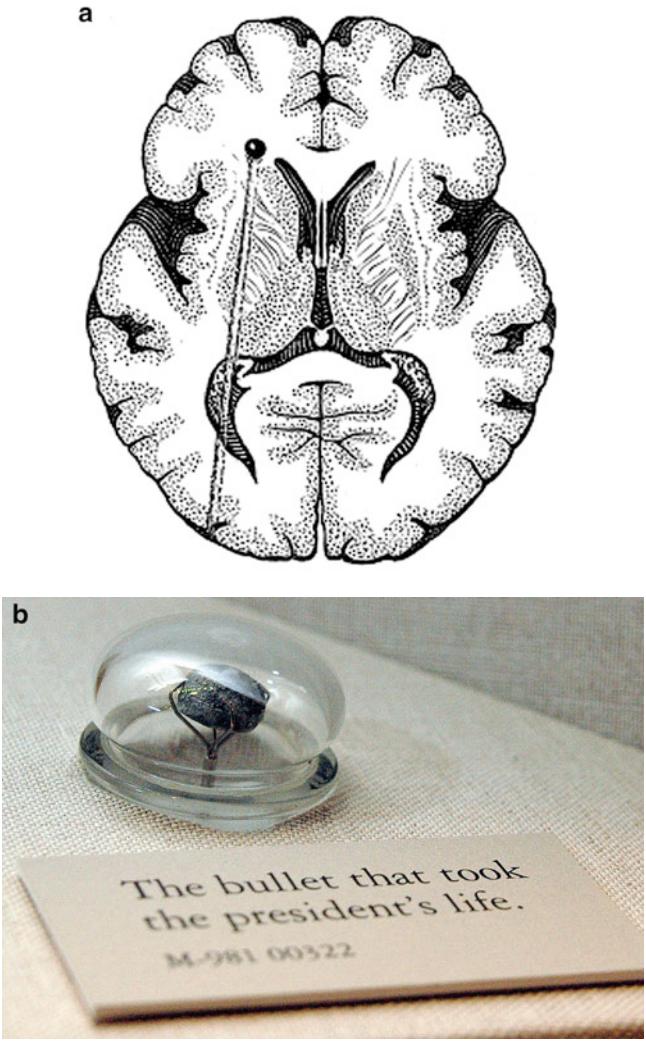

Fig. 1.2 (continued) (**a**) Artist drawing of an axial slice (not dissimilar to a modern-day CT slice) is housed in the National Museum of Health and Medicine, Armed Forces Institute of Pathology, Washington, D.C. (founded, ironically, by President Lincoln on May 12, 1862). Donated graciously with permission to reprint by the National Museum of Health and Medicine, Armed Forces Institute of Pathology. (**b**) This photo is of the bullet that killed President Lincoln on April 15, 1865. It was removed at autopsy in the White House by Army Medical Museum surgeons Lt. Col. Joseph Woodward and Major Edward Curtis and is still. This is a photo of the display at the National Museum of Health and Medicine, Armed Forces Institute of Pathology, Washington, D. C. Donated graciously with permission to reprint by the National Museum of Health and Medicine, Armed Forces Institute of Pathology

prepare military paperwork, personal items such as wills and paying bills while away, etc. Time for specific training for the work a radiologist does in combat is typically overlooked and pushed to the side as other tasks become more apparent and overwhelm the deploying member. Training for an Air Force radiologist for example, occurs once they arrive in the theater of operations. At that point, it is too late to brush up on any skills or learn the specifics of penetrating trauma, workflow in a combat hospital, understand military specific terminology, among others.

All military members, to include all doctors, are provided basic survival courses in the beginning of their career. There are additional optional environmental survival courses in the military (winter, arctic, water, mountain, jungle, etc.), however, these are generally reserved for more operational military positions (pilots, flight surgeons, civil engineers, infantry, etc.).

1.5 Trauma and Critical Care Imagining Training

At the larger military hospitals where several radiologists have deployed experience, those preparing for deployment have an opportunity to obtain informal preparation. Radiologists stationed in smaller medical facilities (such as superclinics) do not have those advantages and often seek other means of honing trauma skills or getting refreshed before deploying. Taking vacation time is often necessary to visit trauma level 1 facilities to experience the flow, pace, and techniques. Some will become familiar on the equipment they will be working on by going to hospitals that have similar equipment. For example, not every hospital performs MultiPlanar Reformation (MPR), Maximum Intensity Projections (MIP), or 3D volumetric reconstructions on a regular basis. These are performed on a daily basis in combat hospitals as this book will highlight. Military radiologists are generally aware that using different equipment when starting in new hospitals can be challenging. Familiarity with vendor specific workflow is imperative before fluency is gained.

Other informal training includes exposure in busy civilian or military trauma centers for days to weeks. Unfortunately, this is often on the radiologists' own time since there is no formal mechanism in place to allow for radiologists' absence from their current jobs to visit other hospitals. While stationed at USU, I overhauled an existing readiness skills verification website for minimal training requirements for deploying radiologists [5]. I developed a curriculum, included my After Action Report (AAR) based on experiences in Iraq, to include equipment used and trauma protocols. I also included a quiz with images and multiple casualty scenarios. We also developed an imaging trauma simulator using PowerPoint, including cases to accompany manikin simulators at our annual Bushmaster exercise, first used in 2008. As students are challenged with simulators that stop breathing, pulse, and interact with ACLS protocols, unknown X-rays and CT images are presented to simulate CXR, pelvis, CT to take scenarios to the next level.

1.6 Air Force Radiologist Training

Formal trauma training for radiologists is under development to include a draft curriculum and course at R Adams Cowley Shock Trauma Center in Baltimore. This could fall under the existing deploying course structure called CSTARS. This stands for Center for the Sustainment of Trauma and Readiness Skills and is for deploying physicians, nurses, and medics, however, has not traditionally included radiologists. This has recently changed and a CSTARS-R (CSTARS-Radiologists) trial course has begun at Baltimore Shock Trauma. This 3 week course will be taught by trauma surgeons and radiologists to help prepare radiologists for deployment. I spent 4 years pushing for a course for deploying radiologists, and it finally became a reality by the time I retired from the Air Force in 2009.

One radiology technique that pushed me to advocate a course such as the CSTARS-R program was the identification of ballistic wound paths using our new MDCT. The images that we obtained allowed us to diagnose and treat hundreds of penetrating ballistic injuries. I was afraid that without a course to teach inbound radiologists how to assess ballistic injuries, many casualties would go improperly treated. As battlefield imaging became more advanced, deployed military radiologists were becoming increasingly convinced that ballistic injuries were more detectable than ever before. My second deployment to Iraq in 2007 was timely in that the scanners used were to be among the first multi-slice CTs on the battlefield. Weeks after the first MDCTs were on the front lines; it seemed that radiologists were desperately trying to pass on the valuable knowledge regarding wounds paths. This significantly aided our trauma surgeons when deciding who to triage to the operating room. We used the wound path to identify injuries that may have gone unrecognized otherwise. We know that when it comes to penetrating head trauma, real estate is everything (location, location, location). In addition, it is known that trajectory determination helps in critical organ identification in the abdomen [6, 7]. For example, one of the major criteria for determining a diaphragm injury was highlighted by Sliker in 2006. Sliker determined that the trajectory/ path of a missile or knife raises suspicion of a diaphragm injury [8,9].

Let us take trajectory analysis a step further, rather than forward in time, back to 1865, the assassination of President Lincoln. After being shot in the back of the head at Ford's theater, he was tended to by several physicians and surgeons that knew his condition was grave (hours to live). See Fig. 1.2a for the trajectory best mapped out by the scientific medical knowledge at the time. Had President Lincoln been rushed to the nearest trauma facility and undergone a CT, based on my experience, he would not have survived despite medical advances. There has been some vector analysis in neurotrauma that supports injury to the area in this drawing that indicates this is a fatal injury by Kim et al. [10]. They had termed the terminus of this ballistic as the "zona fatalis" in that in their study, all injuries to this area were fatal. See Fig. 1.2b for the bullet that ended the President's life. The AFIP, originally called the Army Medical Museum, was founded by President Abraham Lincoln on its original

mission to collect pathological specimens and case histories of Civil War soldiers to facilitate research to improve wartime medicine.

In Chap. 5, I will highlight recent research on wound path identification and trajectory analysis; to the point where radiologists can help scene investigators in identifying the direction a sniper shot from (for example), or the location and strength of a bomb blast based on the fragment patterns in the body from CT imaging.

1.7 Radiology Equipment Challenges

There are challenges in combat environments that make running complicated radiology equipment 24–7 difficult. Weather and climate conditions make the logistics and maintenance of CT (for example) a constant challenge. Overseas power sources are often 50 cycles instead of 60 cycles, and are not often 220 V. Local outlets are not standard US; however, facilities are built similar to US, thanks to military engineers and logistics personnel. At the time of this writing, there is no role for MRI in combat conditions. With high turnover rates of personnel, number of casualties with metallic fragments in unpredictable locations, a compromise of ferromagnetic hygiene would be inevitable. In addition, the support is not available to maintain MRI in combat conditions.

See Fig. 1.3 to highlight the dusty environment of the tent facility. This was the radiologist reading room before moving to the new hardened facility in 2007. There

Fig. 1.3 Radiologist reading room in the tent facility. Note the sand/dust over much of the equipment

Fig. 1.4 (**a–d**) Putting together the new reading room while building the new facility

were times during sand storms that the entire reading room was filled with dust and one had to wear goggles to see just a few feet. This was remedied after moving to the new facility; see Fig. 1.4a–d for the building of the new reading room. As Chief of Radiology, I made sure there was radiologist input in the location and design of the reading room and efficient flow of patients through the radiology department.

1.8 Redeployment, Preparation to Return Home

Lastly, one needs to consider how to prepare to redeploy, or return home. This may seem trivial compared to preparing to deploy in the first place, however, there are many items to consider. There are five stages of military deployment: predeployment, deployment, sustainment, redeployment, and postdeployment. One must be proactive in preparing their own flight home by providing any specifics about their orders and base that deployed them. Allowing work to overwhelm, you can precipitate an item being overlooked, causing delay in flights back home (for example). There are home preparations that need to be arranged and family back home is not used to having the military member around [11].

One common problem shared by many returning military personnel is driving or being a passenger in a car. Deployed military are limited to small bases with little

driving experience. Even when driving on a small deployed base, speeds are below 30 miles per hour. Another problem medical providers have is how trivial many issues are such as forms, red tape, even cases seemingly exciting to many civilian radiologists. Tolerance to seemingly mundane tasks is significantly lowered. Lastly, once out of the desert, colors seem vivid and unreal since one is used to desert sand, drab uniforms, and military setting. The intensity of the colors almost seems like a visual overload; with difficulty explaining how much color we have in the US. I believe some of us take what we have in America for granted.

1.9 Summary

This chapter has hopefully introduced the combat hospital setting, painting the picture of the radiologists' life in this new and unusual world. Before a deployment to a combat zone, there are basic challenges of what to pack and prepare for, in addition to all the military clothing and equipment. The challenges of preparing mentally and physically for deployment were discussed. This chapter should set the scene for upcoming chapters to provide a feel for limitations and challenges and how they were dealt with and expansion of creativity necessary to work in such hostile and austere environments.

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