Operating in Unfriendly Territory: Eye Injury Readiness Kits For Deployment, Humanitarian Aid, and Mass Casualty Events

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The management of eye injuries and diseases during deployment, disasters, and mass casualty (MASCAL) events, humanitarian missions, and expeditionary situations presents unique challenges. Harsh climates, remote locations, power outages, broken and missing equipment, surgical personnel unfamiliar with ophthalmic surgery, and limited facilities for performing ophthalmic procedures are a few of the many difficulties facing ophthalmologists in these situations. Given these realities, ocular care in austere environments – whether as response to disaster, a component of volunteer humanitarian missions, or as an operationally deployed medical force – demands that the personnel involved be innovative, resourceful, and flexible. Non-traditional methods may be necessary when encountering cases that require inaccessible equipment, individuals, or knowledge. These situations will stretch an ophthalmologist's ability to provide comprehensive care. This article will examine the preparatory planning regarding diagnostic and surgical equipment needed for operating outside the normal comfort zone of an established hospital, surgical center, or office.

Medical care in combat. (Source: U.S. Air Force)

Eye Injury Readiness Kit for Deployment

Operational deployment to an expeditionary U.S. Army or Air Force military treatment facility (MTF) or to one of the U.S. Navy's hospital ships or ground-based facilities can be a challenging experience. The deployed environment is very different from the modern, well-equipped civilian or continental U.S. (CONUS) facility, and its familiar equipment, procedures, and personnel. In addition to providing the best medical care possible to both U.S. and coalition forces and their civilian personnel, there is an expectation that medical care will also be provided to patients from local populations, both military and civilian, and even wounded insurgents, particularly if local medical infrastructure is compromised, degraded, or absent. Language, cultural, and religious differences may play a part in the care that can be provided to the latter groups. Issues involving post-operative care, appropriate medical management by local medical providers, and lack of adequate follow-up care for local nationals are other factors that can affect the care provided to these groups. Nonetheless, military physicians and MTFs must provide the best possible care to our active duty personnel, coalition forces, and others whom they are duty-bound to assist.

Deployed facilities can be temporary, semi-permanent, or permanent. Shipboard equipment may need to be secured to prevent movement. Patients may be undergoing different surgeries at the same time, with different services simultaneously involved in their care. There

may also be instances where multiple patients are being operated on in the same operating room. In a zone of conflict, shelling and explosions may be taking place simultaneously with patient evaluation and surgery, causing floors to vibrate or shake. While patients seen in the average CONUS MTF will often have the same everyday vision problems, patients in a zone of conflict will often have injuries that are considerably more extensive, involve polytrauma, and require damage control ophthalmology rather than definitive interventions. In addition, in-fight care will have to be provided for casualties requiring aeromedical evacuation. There may be environmental factors that affect patient care such as electrical failures, overheated equipment, heat and humidity that overwhelm air conditioning systems, severe cold temperatures that overwhelm heating systems, dust storms that render equipment inoperable, and equipment failures and breakage without any possibility of repair, available backups, or replacement. There are also issues of supply and resupply of consumables and medications which require replenishment by air, sea, and/or motor transport from distant locations. In addition, deploying health care providers who have grown accustomed to a specific brand or model of equipment (e.g., operating microscope, slit lamp, sutures, and needles) may not have it available to them in the field; this will require them to operate with equipment which they may not be as comfortable using. These factors, and others, have a significant impact on medical care in the deployed environment. Therefore, adaptability and innovative thinking are important traits for deployed health care providers. If one type of suture is not available, then another can be substituted. Similarly, if one piece of equipment is broken or missing, another may work just as well. Sometimes, it may be necessary to jury-rig or improvise an instrument to do the job.

Medical equipment kits that are assembled for deployment vary by Service, purpose, and medical specialty. The U.S. Army medical equipment sets are known as the Deployable Medical Systems (DEPMEDS), the U.S. Navy as the Authorized Medical Allowance List (AMAL), and the U.S. Air Force as the Expeditionary Medical Support (EMEDS). A kit for expeditionary operations will not be the same as one for a large, fixed, Role 4 facility with subspecialty care availability or one assembled for a more portable and temporary Role 2 MTF without an ophthalmologist, or for a relatively temporary Role 3 combat support hospital (CSH) with a comprehensive ophthalmologist. The components of these kits will also vary based on the medical doctrine and perceived care roles of each military Service. As an example, the U.S. Army will always have an early role in expeditionary operations and must tailor ophthalmic

Soldiers conduct a joint inventory of new medical equipment and supplies during fielding operations with the U.S. Army Medical Materiel Agency. (Source: Ellen Crown, USAMMA PAO)

equipment for the high mobility inherent in that role. Comparatively, the U.S. Air Force may initially deploy an ophthalmologist only to a more mature and developed airhead, whereas the Navy may primarily foresee a sea-based mission. These realities must be reflected in their equipment, personnel, and logistic support.

There are specific considerations for the equipment and supplies at each facility where ophthalmic care is provided. On a very basic level, the number of patients and their conditions that a specific facility can be expected to evaluate and treat over a specified period of time is particularly important for the initial and subsequent supply of disposables and consumables, such as medications, surgical drapes, sutures, gauze pads, scalpel blades, syringes, needles, bandages, and the large number of other items that are used and discarded while caring for patients. Large items used for ophthalmic surgery have a significant number of specific requirements that must be met before they can become part of a particular medical equipment kit. All large surgical items (e.g., a surgical microscope; vitrectomy machine; phacoemulsifcation machine; lasers; surgical stools and beds; slit lamps; and other similar large but fragile items) must be constructed as light-weight, yet sturdy as possible to withstand travel to distant locations without breakage or misalignment. The equipment must be able to tolerate a large range of temperatures without failure, remain in working order in the fine sand blown around in desert locations, and remain effective with the constant vibrations associated with repeated detonations of explosive ordnance. Large equipment should be somewhat modular for ease of transport, while also allowing straightforward reassembly for use upon arrival at the deployment location. In many cases, the ophthalmologist will not only have to know how the equipment should be reassembled but may be the one performing the reassembly. If possible, large surgical equipment should be able to operate under portable and rechargeable battery power as well as standard electrical power. Finally, this equipment should be relatively immune to mechanical failure, and if malfunction or misalignment occurs, should be easy to repair on-site without the need for either a specialized factory-based technician or a return of the machine to the factory for repair (both of which are unrealistic in a combat zone). The U.S. Army Medical Materiel Agency (USAMMA), the Army's executive agent for strategic medical acquisition and logistics, has specific durability requirements that equipment must meet prior to acquisition.

Ophthalmologists repair an orbital fracture at the Air Force Theater Hospital, Joint Base Balad, Iraq. (Source: U.S. Air Force)

The current Army DEPMEDS kits for ophthalmology contain a fairly comprehensive number of instruments and equipment for performing almost any modern ophthalmic surgical procedure in any of the ophthalmic subspecialty areas, though specific and specialized items may be lacking. Some items may be included in other sets, such as the equipment kits for

otolaryngology or maxillofacial surgery for oculoplastics. However, with some ingenuity and a willingness to use a different instrument, it seems evident that the current deployment kits are more than adequate for working in a deployed environment. The DEPMEDS kits also contain all of the necessary equipment for a complete ocular examination. While the examination equipment in the deployment kits is sufficient for performing a comprehensive exam, patients requiring more sophisticated diagnostic evaluation will likely have to be evacuated to a higher echelon of care where such specialized equipment is available. While surgical loupes are included in the DEPMEDS kits, it is recommended that deployed ophthalmologists bring their own personal loupes, particularly if they are fitted with prescription lenses, and any particularly favorite instrument.

Equipment lists containing large and expensive items for ophthalmic surgical procedures are required to be re-evaluated every 3-5 years. Doing so should be the responsibility of the Army, Navy, and Air Force specialty consultants. Routine review of the currency of the lists is a fine balance within ophthalmology given the rate at which new practices and methods are adopted and the rate at which technology advances. Although the goal is to provide expeditionary care that is comparable to the care provided stateside, it would be unreasonable and expensive to make sweeping changes to the equipment kits on a frequent basis, therefore concessions must be made to ensure that ophthalmologists are familiar and comfortable with the equipment as fielded. With that being said, the instruments, equipment, supplies, and consumables on the current list should be routinely re-evaluated in light of availability, capability, cost, and newer items and requirements that may have arisen since the list was last evaluated. This may result in modifications to the deployed ophthalmic surgical and clinic kits. While the medications and sutures currently in the DEPMEDS kits are comprehensive, newer medications and therapeutic items may not be included.

Instruments that have been in constant use for a number of years should be evaluated to determine whether they require replacement as a result of wear (e.g., whether the forceps tips still meet or if all of the scissors still cut properly). Before deployment, the deploying ophthalmologist should be in contact with the person he or she is replacing to discuss any problems with instruments, sutures, medications, and other items they may have encountered. It may be difficult to obtain replacements for missing or damaged items or to resupply needed consumables in a timely fashion while at a deployed site, therefore it is likely reasonable to bring some of these items at the time of deployment (particularly during expeditionary or insertion phases).

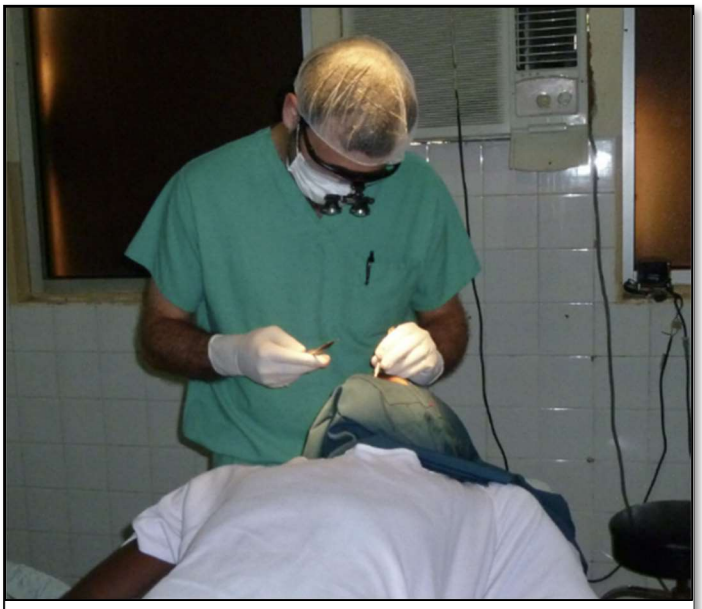
Experience shows that, other than items that are already in the field, many items currently in the depot equipment kits are still in their factory packaging and have not been organized into usable deployable sets. Several previously deployed ophthalmologists have indicated that, just prior to shipping out, considerable time was spent removing instruments from their packaging and organizing them into sets for surgery. Organizing sets prior to deployment and repacking them for shipping would improve efficiency, reduce stress in the deployed environment, and help to identify any instruments that are missing or need replacement. Prior to deployment, it would also be beneficial to examine and learn how to reassemble all major equipment that is shipped in disassembled parts. This is a better approach than attempting to accomplish this at the time of the casualty's arrival for surgery. These considerations are important for all military eye care providers (e.g., ophthalmologists, optometrists), who must be familiar with deployment kit equipment and develop such familiarity

by actually examining the contents of the equipment kits before deployment. This is especially true for care providers who are in deployment billets, and especially so during peacetime when equipment kits tend to be inadequately surveyed. It may also be beneficial to carry electronic versions of essential texts in a cell phone or computer that can be used as reference when evaluating difficult cases and performing unfamiliar surgery. Also important are the various dilutions of medications for either injection or fortified drops in case this information is necessary. Any other important information, such as contact information for particular ophthalmologists or other physicians who can be turned to when advice is needed, should be brought in hard copy and/or electronic versions when deployed.

While this overview has highlighted some of the equipment and challenges that may arise during deployment, humanitarian missions also require deploying ophthalmologists to adapt, improvise, and innovate with the equipment available to them.

Eye Injury Readiness Kit for Humanitarian Missions

The primary challenge that health care providers face during humanitarian missions is being able to provide as high a standard of care as possible – one that they would be comfortable providing stateside, without compromising patient safety or medical ethics.


Operating Room in Haiti. (Source: Dr. James W. Karesh)

In addition to the pre-travel necessities for foreign travel (e.g., vaccinations, visas, passports), there are several required prerequisites before embarking upon a humanitarian mission. An invitation to enter a country for the purposes of providing humanitarian medical care and performing surgery is essential, as is the support of the host country's physician(s) for identifying patients and medical facilities for surgery. This contact is important for successful navigation through the host country's bureaucracy, providing language/translation support for communicating with patients and their families as well local medical staff, and ensuring adequate post-operative follow-up for patients. One should remember that in the developing world, most individuals live in remote areas, have limited access to transportation, must travel along dirt paths or unpaved roads, lack access to modern improved sanitation, and have very limited financial resources for purchasing medications. As with deployment, cultural considerations may influence the perception, acceptance, and solicitation of "western" medicine. Additionally, there may also be limited or no access to imaging equipment such as a computed tomography (CT) scanner or magnetic resonance imaging (MRI), no access to ophthalmic subspecialists such as a retina surgeon, no tissue bank for corneal transplants, and no specialists in fields such as oncology, pathology, and radiation oncology. These realities will

greatly influence the types of surgeries that can reasonably be performed, the post-operative follow-up, and the final treatment outcome.

Before embarking on a humanitarian mission, it is important to conduct a site visit to obtain basic information about working medical equipment, instruments, supplies, and operating facilities available at the location(s) where patients will be evaluated and treated. This will guide preparation of equipment, instruments, supplies, medications, and other items needed for the mission. It is necessary to determine the local, in-country electrical current. In North America, instruments requiring electricity are designed to operate on 110-120VAC (volts alternating current); however, most of the world uses 220-240VAC. As such, a voltage converter and plug adapters are needed to use North American instruments in most foreign countries. In many developing countries, reliable electric power is not guaranteed, despite advance assurances. This will interfere with the use of surgical equipment and lighting, as well as refrigeration and air conditioning. To guard against this and its effects on patient care, a number of alternate energy options are available. One solution is a portable generator for backup power. However, this adds bulk and weight to the equipment needed for a mission and requires a source of fuel. Another option is a solar-powered generator. These work well but are limited in the amount of power that they can generate. When possible, the best solution for unreliable electrical power is to use battery-powered surgical and examination equipment. However, with few exceptions, larger ophthalmic equipment such as an operating microscope and phacoemulsifcation and anterior vitrectomy machines require generator power to operate. External surgical lighting is available through the use of portable floor-stand or pole-mounted LED surgical lighting and battery-powered LED surgical headlamps. These work extremely well as sources of illumination for performing extraocular surgical procedures. Spare bulbs and several extra fully charged, back-up batteries are required for all battery-powered instruments and equipment. During the planning stages, it is important to remember that the success of the mission should not depend on a single factor. For example, if all mission equipment requires electricity, a power outage can render it entirely unusable and thereby significantly hinder the ability to provide care. In such instances, it is critical to develop a plan that includes backup equipment and techniques that are not solely reliant on electricity. When gathering equipment prior to the mission, additional considerations must be made for infection control, sterilization, and for situations that may exceed the capability of the equipment and personnel.

Eye exam being performed on a host-country national
(Source: Dr. James W. Karesh)

On most humanitarian missions, the host country provides information outlining expectations for the mission, including the types and varieties of patients that will be seen. Generally, the

majority of the patients will have dense cataracts, strabismus, glaucoma, or orbital, lacrimal, and/or eyelid problems. Patients can range in age from infants to the elderly. Common operations include cataract and glaucoma surgery, strabismus correction, as well as a variety of oculoplastic procedures, particularly those for correction of eyelid abnormalities caused by trachoma, removal of malignant and benign tumors, surgery for unrepaired or poorly repaired eyelid, orbital, and facial trauma, and surgeries for congenital anomalies. Similar to deployment, it is difficult to perform most retina surgeries due to the potential lack of ophthalmic subspecialists, limited access to expensive and difficult-to-maintain vitrectomy equipment, intraocular lasers, intraocular gases, and the other essentials of modern vitreoretinal surgery.

Prior to arrival, mission leaders may have been informed that there will be access to the following equipment: a microscope for ophthalmic surgical procedures, machines for phacoemulsifcation, electrocautery, biometry, suction, hand instruments for anterior segment and plastics procedures, an autoclave, viscoelastics, sutures, ophthalmic medications, and other necessities for ocular surgery and eye examination. This must be verified, particularly on an initial visit to a host country or new location. It is likely that repeated missions to the same host location will be needed before it is possible to have a true understanding of the working equipment and instrumentation available and the types of surgeries that can be performed. Mission leaders should become familiar with the facilities in which their team will operate. It is critical to know whether the facility is a hospital or a building that has been repurposed to facilitate patient care. Mission leaders and personnel should be familiar with their facility's floorplan for patient flow, particularly as it impacts the location of the clinical evaluation space, pre- and post-operation areas, operating rooms, and potential in-patient beds.

With these limitations in mind, the recommended basic surgical equipment needed for most humanitarian missions should include a portable clamp-on ophthalmic surgical microscope, 2.5x or 3.5x surgical loupes, a portable machine for performing phacoemulsifcation and anterior

Operating room in a foreign nation. (Source: Dr. James W. Karesh)

vitrectomies (if such procedures are to be performed rather than extracapsular cataract extraction), a portable A-scan or A/B-scan ultrasound, and, possibly, a small tabletop instrument sterilizer/autoclave. The amount of equipment to include for the mission will depend on the number of surgeons accompanying the trip and the number of expected cases.

In addition to surgical equipment, it is usually necessary to bring portable equipment for performing eye examinations. Most of these instruments are either battery powered or do not require any power source to function (but will require power to recharge). Essential examination equipment includes direct and indirect ophthalmoscopes, a portable battery-powered slit lamp, pen lights or another focused light source, vision screening chart, and a camera for documentation purposes. Other specialized devices that may be useful include YAG and diode lasers, and a portable keratometer/refractometer.

In areas without reliable electricity, consideration must be given to primary and alternate methods of instrument decontamination and sterilization. A bipolar and monopolar electrocautery unit with sterile monopolar and bipolar cords, grounding pads, and disposable electrodes are other important pieces of equipment. Single-use, low- or high-temperature battery-powered or hand-held cautery instruments are helpful for many procedures, including simple oculoplastic procedures. Small incision manual extracapsular cataract extraction is often performed when phacoemulsifcation is not possible due to the hardness of the cataracts seen during humanitarian mission or when a phacoemulsifcation machine is unavailable or non-operational due to a lack of electricity. Instruments needed to perform this surgery, as well as other anterior segment surgeries, are listed in **Table 1**. These lists are only suggestions; the ophthalmologists for each individual humanitarian mission need to make their own decisions regarding necessary equipment and supplies.

Table 1. Instruments for Cataract/Anterior Segment Surgery During Humanitarian Missions

Muscle hook	Right and left corneal scissors	Olive tip cannula
Lens loop	Lens loop irrigating cannula	#27 angulated cannula
Colibri forceps	Beaver handle and chuck	Vannas scissors
Iris spatula	Fine-tooth forceps (0.12)	Irrigating vectis cannula
Sinskey hook	Large fixation forceps	Jaffe lens manipulator
Utrata forceps	Large locking needle holder (oculoplastics)	AC maintainer
IOL forceps	Blade breaker and razor blades	Cystotome (or 25-gauge needle)
Wire lid speculum	#18 straight cannula	J-cannula
Caliper	Simcoe I/A cannula and tubing	Mosquito hemostats
Stevens scissor	#19 fat angulated cannula	15-degree super blade
Westcott scissors	Angled McPherson and straight tying forceps	Cyclodialysis spatula
Trypan blue	Disposable angle crescent blade	Disposable keratome
Sharp iris scissors	Small locking needle holder (cornea)	Bipolar fine tip forceps

In addition to these instruments, it may be necessary to bring separate sets of instruments for oculoplastic and pediatric/strabismus procedures (**Table 2**). Basic strabismus and lacrimal probing sets should suffice for pediatric procedures. Most facilities in developing countries will not have adequate instrumentation for oculoplastic procedures unless ear, nose, and throat (ENT), maxillofacial, or plastic surgery procedures are also performed in those

facilities. Information in Table 2 is based on the experience of a number of individuals who have participated in humanitarian missions.

All humanitarian missions should bring adequate supplies of disposable items such as #11 and #15 Bard-Parker type blades, appropriate Beaver and keratome blades, Weck-Cel® sponges, cotton-tipped applicators, gauze pads, syringes, needles, and similar single-use items. Thirty-gauge needles and 1cc syringes for intraocular injections and short 25- or 23-gauge needles for corneal foreign bodies should also be brought. It is also necessary to bring gloves, surgical gowns, masks, surgical antiseptic preps for the surgeon's hands and patient preparation, alcohol pads, and other similar disposable items.

Table 2. Surgical Instruments for Oculoplastic Procedures During Humanitarian Missions

Mallet	Heavy and medium locking straight Castroviejo needle holder	Bowman lacrimal probes (various sizes)
Bayonet forceps	Putterman conjunctiva-Muller's muscle resection clamp	Tapered pointed lacrimal dilators
Muscle hooks	Chalazion clamps (various sizes)	Micro Adson forceps
Bone rasp	Chalazion curettes (various sizes)	Locking lid speculum
Blunt scissors	Desmarres retractors (various sizes)	Bard-Parker blade handles
Evisceration spoon	Angled up-oriented thin plate Kerrison punches (various widths)	Curved Metzenbaum scissors
Westcott scissors	Bone rongeurs (double action)	Straight sharp iris scissors
Lid plates	Putterman Gladstone or Waddell clamp for trachoma surgery	Various blunt and sharp skin hooks
Nasal speculum	Suction cannulas (various sizes)	Bipolar cautery forceps
Hemostats	Sharp and blunt periosteal elevators	Malleable ribbon retractors
Wright needle	Various Forceps (e.g., 0.3mm, 0.5mm, Bishop- Harmon)	Instrument case (sterilizable)
Towel clamps	23 gauge guarded straight lacrimal irrigating cannula or 23-gauge IV catheter	Osteotomes/bone chisels
Corneal shield	Crawford lacrimal probe retrieval hook	

A sufficient supply of sutures, particularly sutures needed for microscopic surgery (e.g., 8-0, 9-0, 10-0 nylon) is extremely important; these are frequently unavailable or in short supply in most developing countries. It is also important to bring the suture needed for oculoplastic procedures (e.g., 4-0, 5-0, 6-0 polyglactin 910, silk, and polypropylene) as well as other disposable items used for oculoplastic surgical procedures, such as tubing for stenting the lacrimal system and material for performing suture sling procedures, as these items are often unavailable since oculoplastic surgical procedures are less frequently performed than cataract surgery. It is also necessary to bring a supply of injectable anesthetics, such as lidocaine with epinephrine and bupivacain, as the generics of these medications that are available in developing countries frequently lack adequate effectiveness and duration. The same is true for many ophthalmic medications including injectable steroids and antibiotics as well as diagnostics including dilating drops, sterile saline and water, ophthalmic antibiotics and antivirals, glaucoma medications, topical steroid drops, artificial tear preparations, and other topical medications that might be necessary for managing patients with conditions affecting the eye. Some of these may be unavailable, out-of-date, or made in-country to different standards. Costly viscoelastics are frequently in short supply and must be brought on all humanitarian missions. Fluorescein test

strips or drops are useful for wound leaks, corneal epithelial abnormalities, and evaluation of tear drainage. Schirmer tear test strips may also be helpful.

It is also necessary to bring a number of different kinds of surgical implants for humanitarian missions. These include spherical enucleation implants and conformers, Crawford-type tubing with a Crawford hook (for lacrimal surgery that can also be used as sling material for correcting severe ptosis), and intraocular lenses (IOLs). Spherical enucleation implants composed of methyl methacrylate or silicone spheres are inexpensive and associated with relatively few post-operative problems. Marbles are a reasonable substitute for these implants. The major issue with IOLs is determining the types and powers of IOLs and their respective quantities to bring for the mission. It is not possible to bring a sufficient number of lenses to meet the needs of every patient who will undergo cataract surgery. Two papers have provided some help with this problem. Lombard et al.[1] developed a formula for IOL power based on population studies for emmetropia. His paper reported that IOL powers between 20.0 and 22.0 D would leave 98% of patients to within ±1 D of emmetropia. In a second paper, Schmitz et al.[2] based IOL selection on partial biometry data using mean population axial length or mean population corneal power. This paper reports that using four IOL powers, 19.0, 20.0, 21.0, and 22.0 D, 82.6% of eyes will fall between emmetropia and -2.00 D on post-operative examination. Using this information, humanitarian missions can bring a relatively restricted range of IOL powers for implantation following cataract surgery. It is recommended that humanitarian aid personnel maintain a log of supplies and IOL powers that were used, keep records of post-operative refractive outcomes and the post-operative medications prescribed by the clinicians, and refine the equipment lists based on their prior experience.

While most surgeries performed during humanitarian missions are carried out using topical or local anesthesia, there will be the occasional surgery that requires general anesthesia. If the host country does not have this capability, it may be necessary to bring an anesthesiologist or nurse anesthetist with appropriate equipment on the mission. This vastly increases the complexity of the mission, requiring pre-operation medical evaluation and testing, ensuring that the appropriate anesthesia supplies are accessible, and facilitating an adequate recovery for the patient. An effective backup plan must be in place for managing patients who may have complications relating to anesthesia. The local population may also be nutritionally challenged and have a variety of poorly treated or uncontrolled diseases. Lack of proper follow-up care may also be an

Host-country nationals awaiting treatment at a clinic.
(Source: Dr. James W. Karesh)

issue; patients who may have complications relating to anesthesia. The local population may also be nutritionally challenged and have a variety of poorly treated or uncontrolled diseases. Lack of proper follow-up care may also be an issue; most missions do not take place at modern hospitals with nurses, so patients are often left in the care of family members after surgery. If an adverse event takes place, a medical professional may not be immediately available to see the patient. It may be necessary to stay an extra day or two (or potentially longer) to see patients in follow-up. If patients are traveling from a considerable distance to receive treatment, depending on the treatment and its invasiveness, the patients should be strongly discouraged from traveling home after the procedure. Housing arrangements and in-patient status capabilities should be in place for such patients. It also may be necessary to make a return visit to the host country to reevaluate patients following surgery. A surgical plan that does not include considerations for follow-up care can place added burden on the host country physicians. It is very important that humanitarian missions provide adequate post-operative patient follow-up and management. It may be possible that a host physician will be willing to take on some of the burden of patient follow-up; however, this should not always be expected.

It is best to carry all instruments and supplies as checked baggage, if possible, to ensure their safe arrival. Shipped items may be delayed in customs or lost in transit. However, missions sponsored by the Department of Defense often have equipment pre-shipped to the local liaison office. Humanitarian missions require significant effort and preplanning. The best information regarding equipment and supplies necessary for a particular humanitarian mission is derived from past experience with missions to the same place or area. For this reason, as well as for cost estimations, it is essential to make a comprehensive list of all items used during the mission as well as all patients who were evaluated and treated. The expectations of the host country, the host physicians, and the patients that are evaluated and treated are that the care provided during the mission will be comparable to the care they would receive in any modern first-world country. Humanitarian missions should not be used as training opportunities for beginner surgeons. In addition, an ophthalmologist also represents his or her country when on a humanitarian mission regardless of sponsoring organization. Anything they do or say can affect the attitude of the patients and other host country individuals towards the U.S. and its government and, if on a military humanitarian mission, towards the U.S. military. Humanitarian missions, for better or worse, represent medical diplomacy. Leaving a lasting negative or positive imprint can have a significant impact on the relationships the U.S. has with other countries. Despite the challenges of performing medical care with limited resources on patients with conditions considerably more advanced than what is usually seen in the developed world, humanitarian missions are amongst the most rewarding experiences for physicians and other health care professionals.

Eye Injury Readiness Kit for Hospitals and MASCAL

Similar to deployment zones and regions that require humanitarian aid, within the U.S., MASCAL incidents can easily overwhelm local medical resources. This reality requires health care systems to be prepared for such incidents by ensuring they have a plan to address the influx of casualties and the necessary equipment to care for them.

While MASCAL incidents are a relatively rare occurrence in the continental U.S., they have become increasingly common due to a variety of causes including improvised explosive devices, industrial accidents and explosions, motor vehicle accidents, natural calamity, active shooter incidents, and domestic terrorism. For this reason, many hospitals, medical systems,

state and local governments, the Federal Emergency Management Agency, and other governmental and non-governmental agencies have developed plans for managing injuries associated with MASCAL events. In rural areas, there may only be a single hospital or clinic available to treat the victims of a MASCAL event. In urban centers, many more hospitals and medical facilities may be able to manage patients. However, it is very unusual for a health care facility, let alone a department of ophthalmology, to have an established plan for triaging and caring for the sudden surge of multiple patients with possible or actual ocular injuries. Patients injured during MASCAL events will have likely sustained systemic polytrauma in addition to possible eye injury and will therefore be primarily transported to a trauma center or the emergency department of a hospital that does not have established ophthalmic capabilities and infrastructure. In such cases, ophthalmologists must be ready to go to these locations to evaluate and manage patients who have sustained eye injuries. A skeleton plan can be useful in improving the allocation of human and medical resources, management of injured patients, and management of patients who are already within the health system or arriving for scheduled care. This section will discuss the portable equipment an ophthalmologist should have available when examining and treating injured patients (e.g., in MASCAL situations) in a space other than the eye clinic or office where patients with ocular problems are ordinarily seen.

First responders and civilians rushing to aide individuals injured in the Boston Marathon Bombing. (Source: Creative Commons)

Ocular injuries represent a significant portion of injuries sustained by survivors of MASCAL events. The incidence of ocular injury was 14% during the fertilizer plant explosion in West, TX, 13% during the Boston Marathon bombing, and 26% amongst survivors and rescuers during the 2001 World Trade Center collapse.[3,4] A recent MASCAL event involving a train

derailment in DuPont, WA demonstrated the importance of principles of efficient ocular evaluation and management within treated in the ED of an urban hospital with robust ophthalmic resources. Fortuitously, the accident occurred when physicians and staff had already arrived to begin seeing morning patients. The ophthalmology department's MASCAL plan ensured that all patients with facial injuries received an ocular evaluation by an ophthalmologist in the ED as part of their secondary the context of a MASCAL event, where a large number of injured individuals were evaluated and survey and before further disposition. To accomplish this, it was necessary to assign personnel to the ED to evaluate arriving patients acutely, as well as ensuring normal ophthalmology clinic functions were accommodated (albeit curtailed). It was also necessary to gather the equipment, medications, disposables, and other items necessary for performing multiple eye examinations and emergency treatment at a site remote from the ophthalmology department. The ophthalmology department had developed the plan based in part upon lessons learned from military deployments and from the MASCAL incidents in Boston, MA and West, TX. In both of those latter incidents, it was noted that ophthalmology was typically consulted late in the management of the injured patient (after the ED). In Boston specifically, only 14% of ophthalmology consultations were requested from the ED and almost 66% of initial consultations came from the operating room (OR) or intensive care unit.4 In addition, rigid eye shields were not necessarily present to protect the eye injuries. The inaccessibility of rigid eye shields compounded with delayed ophthalmology consultations puts patients with eye injuries at risk for further damage to the eye. Therefore, the ophthalmologist must be prepared to go where the patients are, rather than waiting for patients to be referred.

The preparation and equipment needed for diagnosis, triage, and treatment of patients with ocular injuries in MASCAL events are largely dependent on the type of facility to which patients are initially transported. MASCAL events in which the injured are transported to a facility with ophthalmic diagnostic and treatment capabilities will obviously be better prepared than a facility without these capabilities. Regardless of the institution, the ophthalmologist must be prepared to go to where the patients are collected and must prioritize early diagnosis, triage, and treatment of eye injuries at that location. This will dictate the equipment, supplies, and personnel necessary to perform Damage

First responders provide care to an injured civilian. (Source: Creative Commons)

Control Ophthalmology (DCO) to stabilize the globe and prevent further damage to the eye. Early evaluation will also allow the ophthalmologists to coordinate with other trauma services for the overall triage and combined management of the casualties. In-house treatment capabilities might vary significantly between institutions; however, the ophthalmologists arriving at the collection point should be prepared to independently provide emergency treatment, such as lateral canthotomy and cantholysis, copious irrigation for chemical injuries, temporary tarsorrhaphy, and shielding the eye. Ophthalmologists visiting a facility without ophthalmic (such as a general trauma center) must also be able to perform primary ocular surgery in non-ophthalmic ORs with unfamiliar and insufficient equipment and personnel who are inexperienced with ophthalmic surgery. The specifics of the organization, planning, and execution will not be discussed here, as these are dependent upon the individual institution and ophthalmology department involved in casualty management. However, preplanning is essential to eye care during MASCAL incidents – that is, to have all needed equipment, drugs, and disposables collected, organized, checked, and current in an easily transportable container prior to any needed use. In other words, all items needed must be ready to go, 24/7, 365 days a year. Equipment must be checked regularly to make sure it is in working order and that no equipment is missing or needs repair. All drugs must be up to date and any expired items must be removed and replaced. It is probably best to have selected individuals responsible for equipment maintenance and resupply.

The need for equipment portability is based on the simple fact that the best place to evaluate and triage patients with suspected ocular injury is either at the incident site or at the emergency room or similar site where patients are brought. Since ocular injuries are generally identified during a secondary survey of an injured patient, ophthalmologists responsible for providing eye care to individuals from MASCAL events must be immediately available to intervene as soon as a patient's initial resuscitation and are complete. Depending on resources and financial ability, at least two "go-bags" containing disposables, drugs, and hand instruments should be available. Suggested items for these "go-bags" are listed in **Tables 3-6**. The spectrum of ocular injuries that will occur may be somewhat predictable based on the nature of the MASCAL event; therefore, items in the "go-bags" can quickly be modified accordingly. For example, an improvised explosive device will likely cause multiple open-globe injuries with foreign bodies, a chemical/industrial plant explosion will cause severe chemical eye injuries requiring copious irrigation, a motor vehicle accident will likely present cases involving blunt eye trauma and orbital/facial fractures, and gunshot incidents may have fewer, but more severe ocular injuries.

Table 3: Disposables
Sterile oval eye pads
Roll of 1" medical paper or similar tape
Eye Shields (often not available at point of injury and only available in small amounts at EDs)
3" sterile cotton-tipped applicators (CTAs)
Tonopen® covers
Fluids for irrigation, eyewash for general debris, and balanced salt solution (may need to rely on hospital/ED for adequate amounts)
Sutures for minor ocular procedures including 4-0 and 6-0 silk and nylon or polypropylene with P-1 or P-3 cutting needles, 5-0 polyglactin 910 with P-1 or P-3 cutting needles as well as S-14 spatulated needles, 6-0 plain gut

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Table 4: Medication
Topical anesthetics
Anti-glaucoma medications
Ophthalmic antibiotics (drops and ointment)
Mydriatics
Fluorescein/Fluorescein strips
pH test strips
Sterile water or saline for irrigation
Topical steroid drops
Artificial tear drops and ointments

A number of larger and more expensive pieces of equipment are also required to complete the kit for a MASCAL response, particularly if traveling to other facilities. Duplicate sets of most of these items are easily collected and organized. The more delicate and damage-sensitive items should be housed in a sturdy, protective, and portable container. All other items may ft in the same container or smaller separate containers.

Table 5: Hand Tools/Equipment
Desmarres retractors and/or bent paperclips with hemostat
Jeweler forceps
Canthotomy/cantholysis kit
Sutures and suturing instruments /minor surgery instrument tray
Injectable medications (e.g., local anesthesia, steroids, antibiotics)
Punctal dilators
Lacrimal probes
Lacrimal irrigating cannula
Intraocular irrigating cannula
Needles and syringes for injecting anesthetics (3 cc syringes and long 25-gauge needles work well but so do other sizes of syringes and needles)
30-gauge needle and 1 cc syringe for intraocular injections and anterior chamber irrigation or fluid removal
Short 25-gauge needle or 30-gauge needle for foreign body removal
Battery operated hand-held hot temperature cautery
Lid retractor

Table 6: Examination Equipment
Portable slit lamp
Indirect ophthalmoscope
Tonopen®
Direct ophthalmoscope
Pen light/muscle light with blue light filter
20D and/or 28D Hand lens
Loupes
Ruler
Near visual acuity cards
Writing paper and pen/pencil for notes

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These lists should permit an ophthalmologist covering a MASCAL situation to perform complete ocular examinations on all patients with ocular injuries. It will also facilitate urgent interventions such as canthotomy/cantholysis, the repair of simple lid and periocular lacerations and the evaluation of possible canalicular and lacrimal system injuries, and the identification of other serious conditions.

In circumstances where patients injured in MASCAL events are brought to a trauma center or hospital without robust ophthalmic capabilities, it may be necessary for ophthalmologists to perform more extensive surgery at this location that would ordinarily be performed in an OR set up for eye surgery. MASCAL patients will likely have systemic injuries that can only be managed at the trauma center; these patients will therefore remain at the trauma center for further treatment and will not be immediately transferred to an ophthalmic facility. Because of this, ophthalmologists may have to perform urgent interventions, such as repair of certain open-globe injuries, at the non-ophthalmic facility where the patients are initially being sent. As a result, the ophthalmologist will be performing surgery in a non-ophthalmic OR and may only be able to perform DCO procedures (e.g., stabilizing the globe, achieving a water-tight closure, covering the cornea, and managing herniated intraocular tissues and vitreous). By bringing and using equipment and instruments such as a portable operating microscope, a tray of micro-instruments for a variety of DCO procedures, and various disposables and supplies needed for the management of open globe injuries, the ophthalmologist will be able to perform these procedures in a general surgical/non-ophthalmic OR at the trauma center or general hospital.

While the tables included are relatively comprehensive, they are only suggestions/ recommendations. Each department or ophthalmologist assembling a kit for managing patients with ocular injuries associated with a MASCAL event may have a different idea for what those kits should contain. The important part is the need for preparation in advance of any MASCAL event. Generally, it is difficult to prepare for events that are infrequent and random or have never occurred at a particular location. Often the attitude is that the chance such an event will ever occur is so remote that it will likely never happen and that there is no need to spend time and money to prepare for such an event. However, current evidence and experience shows that these events are no longer rare. While this overview outlines the ophthalmic equipment needed in MASCAL situations, there are several other critical aspects of the MASCAL response not covered here that must be considered, such as communication plans, command and control of personnel, and coordination with the trauma center or ED.

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