EMRA

EMS ESSENTIALS

A Resident's Guide to Prehospital Care

Editors: R. LeGrand Rogers, MD; Faizan H. Arshad, MD; and Timothy Lenz, MD, EMT-P

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CHAPTER 1

A Brief History of Emergency Medical Services in the United States

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Prehospital emergency care in the modern age is often described as a "hierarchy" of human and physical resources utilized in the acute setting to provide the best possible patient care until definitive care can be established. Like most hierarchies, the system in place today was forged one link at time, dating as far back as the Civil War. With widespread trauma, a systematic and organized method of field care and transport of the injured was born out of necessity. In 1865, the first civilian ambulance was put into service in Cincinnati, Ohio, followed by a civilian ambulance surgeon in New York 4 years later.[1] The New York service differed slightly from the modern approach, as they arrived equipped with a quart of emergency brandy for each patient.

Military conflicts and necessity provided much of the impetus to develop innovations in the transportation and treatment of the injured. In the wake of World War I, the Roaring '20s saw the first volunteer rescue squads forming in locations such as Virginia and New Jersey. Control began to shift toward municipal hospitals or fire departments as funeral home hearses were slowly joined by fire departments, rescue squads, and private ambulances in the transportation of the ill and injured. Landmark articles in the late 1950s and early 1960s began to detail the science and methods for initial cardiopulmonary resuscitation (CPR), forging yet another vital link in the chain as EMS began its first steps to transition from transport-only into the treatment of prehospital cardiac patients. Departments trained in cardiac resuscitation began to record successes in major urban areas such as Columbus, Los Angeles, Seattle, and Miami.

The 1960s provided another challenge to public health as traffic accidents began to lead to considerable trauma and death. This "neglected disease of modern society"[2] was detailed in the 1966 white paper, Accidental Death and Disability: The Neglected Disease of Modern Society. The paper, prepared by the National Academy of Sciences and the President's Commission on Highway Safety, detailed the injury epidemic and the lack of appropriate prehospital care and an organized system to treat patients suffering from critical traumatic injuries. Reforms were indicated in education and training, systems design, staffing, and response in the nation's ambulance services. The white paper gave way to the National Highway Safety Act of 1966, which established the Department of Transportation (DOT). The DOT and its daughter organization, the National Highway Traffic Safety Administration (NHTSA), were critical in pushing for the development of EMS systems while standardizing education and curriculum standards, encouraging involvement at the state level, and providing oversight into the creation of regional prehospital emergency systems and regional trauma center systems, forming the birth of trauma center accreditation by the American College of Surgeons Committee on Trauma. For the first time in U.S. history, a curriculum standard was being set in skills and qualifications required to become an emergency medical technician. Paramedic education arrived shortly afterward, but it still has a ways to go in terms of scope and depth.

The EMS Systems Act of 1973 provided funding for the creation of more than 300 EMS systems across the nation and set aside funding for key future planning and growth. During this time, EMS grew alongside the development of emergency medicine as a distinct specialty, with the first residency training program approved in 1970, at the University of Cincinnati1. By 1975, more than 30 EM residencies developed across the nation, preparing physicians who would interface with EMS at all levels: from responders and educators, all the way to medical directors.

Advances in care standards and education continued throughout the 1980s with changes in the principles of EMS funding through the Omnibus Budget Reconciliation Act. The act established EMS funding from state preventative health block grants rather than funding from the EMS Systems Act. The role of EMS also began to change towards the front line of healthcare to include chronic diseases, pediatric patients and the underserved. EMS practice was no longer just for adult trauma and cardiac emergencies.

Recognizing the need to advance its own practice while creating a cohesive integration with the health care landscape, the 1996 EMS Agenda for the Future was drafted. The EMS Education Agenda for the Future was published shortly thereafter and described more modern recommendations for core curriculum content, scope of practice, and certification of EMS professionals.[2]

Within the past 20 years, EMS has become a focus of intense research of prehospital interventions into many commonly encountered acute care issues seen in emergency medicine, such as acute respiratory distress, cardiac arrest, chest pain, and trauma. With increasingly integrated technology between prehospital care and the emergency department, patient data is beginning to be transmitted real-time, allowing for earlier determination of patient severity and care management needs prior to arrival. Quality improvement with integrated electronic charting, including patient outcomes, is beginning to provide much-needed feedback as EMS endeavors to become a dedicated subspecialty of emergency medicine. Within regional stroke centers, cardiac catheterization centers, and trauma systems, EMS has become the forefront of emergency medical care and can only serve to advance how emergency medicine is conducted in the future.

EMS has come a long way from the horse and buggy. Growing alongside emergency medicine, there are opportunities for physicians to become involved in many different aspects of the system. While EMTs are not independent practitioners and generally operate under a medical director's authorization, the situations they face require considerable problem-solving, judgment, and clinical decision-making skills. Physicians are needed at every step to help develop treatment protocols, provide quality improvement, hold regular training sessions, and ensure all personnel have the tools they need to perform high-quality prehospital care. In addition, EMS physicians may be called upon for situations that require their presence on scene in the field including mass casualty incidents, high acuity and high-risk scenarios, tactical situations, or patients that require advanced skills such as surgical airways, pericardiocentesis, thoracostomy tubes, and others. Large-scale operations including concerts, conventions, and city events also benefit from physician input.

EMS will continue to be the front line of emergency medicine as the field expands in the coming future. Physicians involved with pre-hospital care will be paramount to providing the support and knowledge required to help EMS systems grow, as evidenced by the recent recognition of EMS as an official clinical subspecialty.

Involvement in the EMRA EMS Division will be a great opportunity for EMRA members with a career interest in EMS as well as those seeking exposure to working with prehospital systems in the future. If you are interested, please feel free to contact us at emsctte@emra.org.

References

1. Zink BJ. Anyone, anything, anytime – a history of emergency medicine. 2006, Mosby Elsevier; Philadelphia, PA.
2. West Virginia Department of Education. "A Brief History of Emergency Medical Services." http://wvde.state.wv.us/abe/Public%20Service%20Personnel/HistoryofEMS.html.
3. NAEMT. "History of EMS." http://www.naemt.org/about_ems/EMShistory.aspx.

CHAPTER 2

Resident Roles & Responsibilities

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EMS training experiences vary between programs. In fact, many programs don't even require ambulance ride-alongs, let alone flight time. With the advent of ACGME accreditation of EMS fellowship programs, a more generalized educational experience across residencies is likely to develop in order to meet standardized expectations of fellowship directors. For the time being, residents should become familiar with their individual program requirements. However, a model curriculum created in 1996 offers some expectation of resident EMS education. The 'Experiential Components' section the curriculum offers a reasonable focus.

Your level of involvement may vary – you might just help here and there with any of the following tasks, or you may wish to become a resident/assistant medical director, working with an attending physician to provide medical oversight for a particular

EMS agency in your area. Regardless of the particular opportunities of individual residency programs, it is critical for EM residents to understand the nuances of EMS medicine and how they differ from emergency medicine.

On-scene Experience: Direct observation allows evaluation of subtleties not captured in written EMS run reports. You will also gain a greater appreciation for what the EMS providers deal with on scene, and their protocols prior to ED arrival. You will also have the opportunity to experience prehospital specific procedures, like backboarding/spinal immobilization, vehicle extrication, and various airway rescue devices. Depending on your residency program you may be in an observer-only role or, as a junior resident, you might operate only under EMS protocols. As a senior resident, you may be allowed to assume on-scene medical oversight, allowing the use of your own clinical judgment, procedures, and skills to perform interventions outside the EMS scope of practice.

Training: Opportunities abound to give a lecture at your local EMS agency, facilitate hands-on training, or lead an interactive review of some recent runs. This can be provided on a set schedule, or in response to specific concerns. For example, if the department has been having trouble with pediatric airway management, you may choose to review those run reports and discuss appropriate intubation and non-invasive airway management options and techniques specific to the pediatric airway.

You may also consider other lecturing opportunities to develop public speaking skills. Check with your local EMS coordinator, training program instructor, or EMS official at your organization to find out about local classes, EMS conferences, and provider courses for potential opportunities.

Medical Oversight: This aspect of training involves online medical direction via phone or radio or offline via protocol development and case review. Each residency program and EMS group will have its own protocols or guidelines for medical direction, so be sure to become familiar with them prior to participating in this capacity. Another means of gaining experience with medical direction lies in quality assurance and improvement activities. The Medical Director, along with the Quality Improvement team, regularly review EMS runs. A robust QA/QI program can recognize systematic as well as individual trends, which may allow for focused training, individual action plans, or a system-wide change. Many regions have a set schedule for this (eg, review of chest pain runs in January, shortness of breath in February, etc.). Others use random chart sampling for a fixed interval, review of sentinel events, or trend analysis. Another opportunity in medical direction experience is the review, creation of, or implementation of protocols. Most EMS providers operate under protocols, which may be designed and revised by groups (a regional physician advisory board or a standing orders committee) or by an individual, like the system or state medical director. Protocols specify prehospital provider scope of practice: what medications/doses they may use, whether they may perform rapid sequence intubation, or if they may call ahead to activate the cardiac cath lab. Involvement in developing and drafting protocols is a great way to learn more about EMS systems at the local, state, or national level, and also is an opportunity to ensure that best medical practices, new and emerging technology, and up-to-date evidence-based medicine is reflected in these protocols.

Disaster Planning: Most hospitals run disaster drills that include patient evacuation, haz-mat, and limited-resource training, and participating at this level is often required. However, as an emergency medicine resident you will need a working knowledge of prehospital disaster management. Mass gatherings like concerts, sporting events, and political rallies often require EMS presence. This is a valuable exposure to disaster planning and to the many aspects of mass casualty medicine. Involvement may include preplanning, evacuation plans, and providing direct patient care at on-scene aid stations. If you are interested in disaster medicine, join your local DMAT (Disaster Medical Assistance Team), or US&R (Urban Search & Rescue) Task Force. Their medical directors help provide training, but their main purpose is to ensure the health and well-being of their crews preparing for and during a deployment. Some states have their own disaster response teams that provide services similar to the DMAT or US&R

Task Force, which can be deployed at the state level without federal approval. Depending on where you live, there also may be opportunities to work with more specialized teams like wilderness or air and sea search and rescue.

Beyond the typical EMS and fire department model

NREMT test item writing: Several times a year, physicians and EMS providers and educators gather at the National Registry of Emergency Medical Technicians headquarters in Columbus, OH, to write test questions for the national certifying exams for EMTs and paramedics. This is another good way to become more familiar with the EMS curriculum, develop your test-writing skills, and contribute at the national level to education and certification of EMS providers.

Advocacy on behalf of EMS, and liaison between EMS and other groups: This is a role that every medical director must fill to some extent. For some, it may be the simple day-to-day communication on behalf of EMS – explaining to hospital-based physicians/nurses why EMS did things a certain way, how they operate, or what their protocols do or do not allow them to do. Others may take this role much further – working with leaders in the community to build a strong local EMS system, or speaking to government officials up to the national (or even international) levels to advocate on behalf of EMS.

SWAT/Tactical law enforcement: These teams are increasingly looking for active EM physician involvement. This includes providing training for their own medics and working alongside the tactical team as a primary medical asset. Opportunities abound in this exciting and expanding area of emergency medicine. EM residents across the country are actively supporting tactical teams at the city, county, regional, state, and even federal levels, including FBI SWAT.

Medical director for EMD (emergency medical dispatch) centers: EMS are the first people to physically see and touch the patient, but dispatchers are the earliest link in the emergency response system, as they answer the phone call and provide verbal instruction for things like CPR and bleeding control, or even walk the caller through delivering a baby.

Flight medicine: There is likely a helicopter transport service of some type in your area. In many ways, flight medicine is similar to ground EMS in that they have specific protocols and require regular training. There are, of course, many nuances specific to the flight service that make this another good opportunity to be involved.

Metropolitan Medical Response System: The MMRS is a federal grant program designed to promote and improve disaster response involving multiple agencies, jurisdictions, and roles. An MMRS may have several smaller committees, focusing on anything from preparation for a mass casualty, to preparing for EMS's response to an active shooter, to planning resources and response for an epidemic disease outbreak. Even if there is not an MMRS active in your region, there is probably some person or agency working on these types of domestic preparedness activities.

References

1. Katzer R, Cabanas JG, Martin-Gill C. Emergency medical services education in emergency medicine residency programs: a national survey. *Acad Emerg Med.* 2012;19(2):174-179.
2. Verdile VP, Krohmer JR, Swor RA, Spaite DW. Model curriculum in emergency medical services for emergency medicine residency programs. SAEM Emergency Medical Services Committee. *Acad Emerg Med.* 1996;3(7):716-722.

CHAPTER 3

Safety

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Safety is a process requiring awareness, experience, and continuous reassessment. It is the primary concern for medical students and residents on EMS rotations. This section will explore common scenes encountered by first responders and will offer guiding principles to ensure provider safety; however, this is by no means conclusive or all-encompassing. The most important principle is to not enter a situation where your safety may be compromised. Your No. 1 priority at all times is looking after your own safety! (Table 1)

TABLE 1.
Essential Safety Attire
Reflective EMS Safety Vest: For any scenes involving traffic or work near moving parts (day or nighttime). Stocked in most units; inquire prior to shift.
Tactical Pants: For exposure to the elements, glass, gravel, etc. Also for carrying essential items. Scrubs are not sufficient.
Goggles/Safety Glasses: Eye protection should be considered for all scenes. Many services are now requiring their use at all calls by personnel.
Bunker Gear: For any rescue operations. Will help to protect providers tending to patients awaiting rescue (eg, motor vehicle entrapment).
Safety Hard Hat: For all scenes involving construction, industrial work, machinery, or moving parts.

Emergency Vehicle Operations

Operating an emergency vehicle is the highest-risk task EMS providers undertake. Should you find yourself operating these vehicles (only after formal training and authorization; very few EM residency programs allow this), follow these general guidelines:

- Emergency response vehicles are requesting the right of way; expect other drivers to deny that request or not understand it.
- More noise is better noise! Utilize the many sound settings on your vehicle to broadcast your intentions.
- For all opposing signals (red lights, stop signs, yield zones), make a full stop and eye contact with other drivers to ensure they see you and understand your intentions. Do not proceed if you are not confident other drivers understand you are responding to an emergency and are requesting the right of way.
- When you arrive on scene, reduce your noise level, but keep lights on even after you leave your vehicle.

Do not operate an emergency response vehicle without appropriate formal training and orientation.

Sizing up the Scene

Make it a habit, no matter the call, to take a few seconds for critical scene assessment. This will also help determine what equipment to take when you do leave the safety of your vehicle.

- **Scene Approach:** Look for obvious hazards first; any mention of hazards on dispatch call?
- **Potential Assault or Harm:** Is law enforcement on scene? If there is any doubt about safety, call for law enforcement to secure the scene prior to your entry! Do not enter the scene without an all-clear from law enforcement personnel.
- **Required Equipment:** Flashlight, traffic or safety vest, helmet or head protection, safety glasses, and personal protective equipment for infection control.
- **Requesting Additional Resources:** Use radio to describe the scene (eg, number of potential patients, entrapment, mechanisms of injury, location, and other potential hazards).
- **Questionable Safety:** Retreat immediately to a predetermined staging area while awaiting law enforcement. Open public areas like parking lots one or two blocks away on a main road allow for quick entrance and exit to main roads, with good scene visualization.

The Motor Vehicle Collision (MVC)

This is one of the most frequent calls EMS responds to, and it entails significant risks to providers. These scenes should not be entered without appropriate traffic control and support from other units.

- Evaluate the scene and determine required resources; do not enter traffic without other units providing traffic control. Watch especially for downed wires, which may be energized.
- Always wear a bright, reflective traffic vest.
- Unstable vehicles: If there a vehicle is unstable, especially in cases of required extrication or any question of fire/combustion safety, wait for fire and rescue assistance.
- Vehicles can be hot: any exposed body area can be burned. Wear appropriate fire safe materials before working with any potential for exposed engine components.
- Ongoing /prolonged extrication or rescue work: establish ABCs, reassure patient, communicate rescue progress, consider pain management options, and begin initial medical care when possible.

Scrubs are not appropriate apparel for out-of-hospital medicine.

Fire, Water Emergencies, and Other Rescue Operations

The type of scene may vary significantly, but the ultimate objective is the same: making sure that providers (and patients!) go home safely at the end of the day.

- **Do Not Enter a Fire Scene:** The fire professionals will handle fire. Wait for patients at designated medical treatment areas. These areas may require your supervision as a physician. Review National Incident Management System (NIMS) mass casualty protocols.
- **Water Emergencies:** DO NOT attempt a water rescue without specific training. Wait for patients at designated areas.
- **Ensure Safety of Medical Treatment Area:** Winds may change, and your location will require periodic reassessment. Consider smoke and hazardous materials flow, and continuously reassess.
- **Scene-specific Provider Health Hazards:** Smoke inhalation, CO poisoning, burns, and hypo/hyperthermia are all risks. Evaluate providers with full exam, and watch for those who need further ED evaluation. Solicit assistance from other fire personnel as needed. Providing simple scene support such as water and cool-down areas can have a significant effect for other responders.

- **Team Dynamic:** Coordinate with incident commanders to find where your talents will be best utilized. ALWAYS check in with a scene commander when you arrive and before you enter any potentially hazardous areas.

Residential/Domestic Scenes

In a metropolitan or suburban area, a common scene for EMS is in the domestic residence. Whatever the location, the basic principles of safety must be considered.

- **Reduce Risk Before Entering Scene:** Hazardous scenes warrant law enforcement involvement. These include assault, use of deadly force (guns, knives, blunt trauma, etc.), domestic violence, psychiatric emergency, drug overdoses, or any high-risk scenarios.

- **Approaching Domestic Residence:** Knock and announce your presence. Stand to the side of doors when waiting for response.

- **Entering Enclosed Areas (apartment, living room, etc.):** Scan for safety, keep eyes on exits, know where you are at all times. Avoid going anywhere alone or without support.

- **Altered Mental Status:** Consider safety aspects involving altered/combative patients/citizens, nature of illness (stimulant overdose, hallucinogen, etc.). Be prepared to use an exit strategy or law enforcement support.

- **Dangerous Situations:** Use an appropriate amount of force to protect yourself/others; metal clipboards, flashlights, and even O2 cylinders can be used to deter assaults. Exit immediately and call for assistance. Inquire about radio emergency code words prior to your shift. Do not retrieve equipment! No amount of equipment is worth a provider's safety.

CHAPTER 4

EMS Delivery Models, Provider Levels, and Scope of Practice

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EMS has evolved into a multifaceted medical care delivery machine with multiple delivery models catering to geographic and demographic needs - each part integral to the whole and serving a specific role. For example, the 911 service may take a call, transfer it to an EMS dispatcher who then triages the call for response by a firefighter, ambulance company, or law enforcement official, each of whom may be a BLS, ALS, or even flight responder. As one can imagine, this takes great effort and organization with clearly defined medical care delivery and provider roles. (Table 1.)

TABLE 1.

Examples of EMS Delivery Models

Examples of EMS Delivery Models
Fire Department or Public Safety
• Frequently acts as first responders until ambulance arrival
• Provision of basic or advanced life support depending on the department's funding, training, and mission goals
• May also have transport capabilities (eg, fire department ambulance, state police helicopter, etc.)
• Some agencies are volunteer-based
Private
• May be part of the 911 system, depending on jurisdiction
• May be for-profit or nonprofit entities
• Frequently utilized for interfacility transfers (eg, skilled nursing facility to hospital)
• May have contracts with hospitals for specialized transfers (eg, neonatal transport, trauma patient transfer)
Volunteer
• Part-time staff who are usually not compensated
• Staffing models vary; volunteers may work at a station during duty shift or be paged to respond
Non-traditional
• Serves to supplement existing EMS system to reduce burden or as a precaution at high-risk events
• Tactical EMS
• Mass gathering/special event
• Search and rescue/technical rescue
• Ski patrol

Additional Definitions

Alternate Transport Vehicle – A vehicle used by an EMS agency to move patients from difficult terrain or unusual situations; can include stretcher-equipped golf carts, specially retrofitted fire engines, and armored personnel vehicles.

Community Paramedic – A service delivery model where paramedics provide home-visit type services, including targeting high-frequency 911 utilizers and patients who are at high risk for hospital re-admission (eg, CHF exacerbation).

Exclusive Operating Area – A jurisdiction, zone, or geographic area that maintains a sole EMS provider that, through a competitive bidding process, has exclusive contractual rights to all emergency transports for a given area.

Fixed Wing Aircraft – An airplane used for EMS transports or specialized medical services such as organ donation transport.

Interfacility Transport – Transfer of a patient between two health care facilities, without the activation of the 911 system. Examples include transferring a patient from a community hospital to a trauma center, or from a skilled nursing facility to a dialysis center.

Multiple Role EMS Agency – Emergency service agency that provides public safety services in addition to its role in the EMS system, such as firefighting, hazardous materials mitigation, or law enforcement. Fire and public safety departments commonly fit this model.

Quick Response Vehicle (QRV) – A non-transporting EMS vehicle (eg, an SUV-type automobile) that is part of the initial 911 system response. Usually staffed by a paramedic.

Priority Dispatching – A system used by emergency medical dispatch agencies to triage the severity of 911 calls in order to allocate appropriate resources. In some areas the dispatching protocol may also dictate if emergency signaling devices (eg, red lights and sirens) are to be used.

Rotor-Wing Aircraft – A helicopter used for EMS transport, and sometimes also for search and rescue.

System Status Management – A dynamic deployment model for EMS resources, which uses historical data to deploy ("post") ambulances where they are most likely to be utilized. (This is in contrast to a fixed deployment model, such as the use of fire stations.)

Tiered Response – Service delivery model in which multiple levels of providers can be dispatched to an emergency. For example, a basic life support fire department is dispatched alongside a paramedic-staffed ambulance when a 911 medical call is received.

References

1. US Fire Administration. Handbook for EMS Medical Directors. FEMA. March 2012.
2. NHTSA. National EMS scope of Practice Model. Publication DOT HS 810 657. February 2007.

TABLE 2.
EMS Provider Definitions & Scope of Practice
Emergency Medical Responder (Previously known as First Responder) — Minimum training standard for many fire, law enforcement, ski patrol, and volunteer EMS squads
Scope of Practice
• Basic life support (eg, bag-valve-mask ventilation, CPR, AEDs)
• Airway adjuncts (eg, oral and nasal airways)
• Oxygen therapy
• Treatment of hemorrhage and splinting fractures
• Manual cervical spine immobilization
• Vital signs assessment, including manual blood pressure
Advanced Emergency Medical Technician (Previously known as EMT-Intermediate)
Scope of Practice Includes skills of Emergency Medical Technician and:
• Supraglottic airways
• Suctioning of an endotracheal tube
• Intravenous and pediatric intraosseous access
• Provision of the following medications: IV fluid therapy, IV dextrose, glucagon, epinephrine (for anaphylaxis), inhaled beta agonists, naloxone, nitrous oxide, and sublingual nitroglycerin
• Blood glucose monitoring
Paramedic (Previously known as EMT-Paramedic)
Scope of Practice Includes skills of Advanced Emergency Medical Technician and:
• Endotracheal intubation
• Cricothyrotomy

- Pleural space needle decompression
- Gastric decompression (eg, nasogastric or orogastric tube)
- Adult intraosseous access
- Cardioversion and defibrillation
- Vagal maneuvers
- Transcutaneous pacing
- 12-lead EKG interpretation
- Continuous positive airway pressure
- Capnography
- Provision of additional prescription enteral and parental medications (eg, lidocaine, amiodarone)
- Maintaining infusion of blood/blood products

Critical Care Transport Paramedic and Flight Paramedics.*
Note: This level of training is not part of the National EMS Scope of Practice Model; requirements are not standardized and will vary depending on agency or jurisdiction.

Paramedics who have received this level of training are typically responsible for high-acuity interfacility transports (eg, transfer of ICU, trauma, stroke, or STEMI patients).

- Additional training in flight physiology, hemodynamic monitoring, lab data, and radiographic interpretation
- Provision of infusions and other medications not commonly used in the prehospital setting
- Mechanical ventilator operation

CHAPTER 5

Before My First Ambulance Ride I Wish I'd Known...

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Paradigm change: *A new patient-care experience, new ways of doing things.*

In the prehospital setting, the disease processes and pathophysiology of the patients we care for are the same – but the priorities, practices, and procedures are often different. Given the austere environment encountered in the provision of prehospital patient care, procedures should be considered entirely new activities as compared to performing them in the emergency department. This is true even for familiar procedures such as peripheral IV starts, endotracheal intubation, and checking vital signs.

1. **Look and listen.** Both for safety and learning, it is important to observe the style and teamwork of the crew you are working with. In-depth questions are often best

asked/answered after the call has been completed at the hospital. EMS work occurs in a dynamic, sometimes volatile, environment – looking and listening more than you are speaking helps keep you safe.

2. **Have fun.** EMS workers are interesting and fun people with amazing senses of humor and unbelievable stories.

3. **Help carry equipment.** If you help with the work, the crew will have immediate respect for you as a teammate. Also, if you carry “the kit” (bag with the most equipment and medications) you can be sure you won’t be left behind on scene.

4. **Be ready for anything**. Chest pain, complete boredom, CPR, childbirth – you might see all of these in one shift. Be sure to bring a snack in case there is no time to stop for food, and bring reading materials in case you have a slow day with a lot of downtime.

5. **Absorb the surroundings.** You often deliver care in a 70 degree, well-lit environment with lots of resources. But EMS delivers care in extreme temperatures, on train tracks, and in shopping malls. Be sure to look around to appreciate EMS crews and where YOUR patients are coming from when they reach the ED. Also, internalize appreciation for what it takes to get patients “packaged,” extricated, and transported to the ED bed.

6. **Participate!** Be ready to evaluate patients, help with spinal immobilization, formulate a differential, listen to breath sounds, and take manual vital signs. Need to practice with a blood pressure cuff beforehand? Don't forget your stethoscope.

7. **Answer questions.** You are a physician and the crew you are working with will be interested in some of the knowledge you have. Interaction with EMS is great practice at simultaneously being a teacher and a student. Never lose sight of the fact that the crew is ultimately in charge of all decisions during your time on their ambulance – they have final say and are responsible for the safety of you and the patients.

8. **Dress appropriately.** Often third riders on an ambulance are asked to wear a white button-down shirt and black or navy blue pants. Regardless, be sure you are dressed modestly and neatly. Footwear is very important – a work boot is best. Dress shoes, slip-ons, and sandals are not appropriate from an appearance, functional, and OSHA perspective. Be prepared for changing weather – rain, wind, snow.

Consider reading *People Care: Career-Friendly Practices for Professional Caregivers* (Thom, Dick, et al) prior to your EMS rotation.

SUBSPECIALTIES

- Mass Gathering, Mass Casualty Incidents, and Incident Command
- Haz-Mat
- Urban Search & Rescue
- Rural EMS
- Nuclear
- Tactical EMS
- Flight
- Fire Ground
- Water Rescue

CHAPTER 6

Mass Gathering, Mass Casualty Incidents, and Incident Command

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Tim Lenz, MD, EMT-P
E. Brooke Lerner, PhD

Mass Gathering

Mass gatherings, recognized as events with relatively large numbers of people, are becoming more frequent. These scenarios present unique problems for health care provision and safety. These differences arise from a high concentration of people, often within venues that have limited or defined space.

Challenges

- Access to traditional EMS can be difficult.
- The resources present can be quickly overwhelmed.
- At a mass gathering, there is a higher incidence of people requiring medical care than the same population in the

general public.

Planning

Large gatherings require deliberate planning, with careful attention to detail. Take into consideration:

- Venue size, layout, number of attendees/density, location, and expected weather.
- Venue entrance(s)/exit(s) and access.
- Social environment: Alcohol sales or consumption, drug use, access to water.
- Population: Elderly, young adults, children, and type of crowd (eg, dignitaries with security teams, etc.).
- Best models are previous events - ideally at the same venue and same previous event. This is often not available, so events similar in scope and population must be used as a comparison.

Providing Care

The role of a resident in a mass gathering event can vary. Keys to understanding your role:

- Know who is charge of medical care (local EMS, Red Cross, hospital, volunteer organization, etc.).
- Be aware of local legislative regulation for the particular

region.

- Know the method of communication (dedicated radio systems, phones, etc.).
- Familiarize yourself with patient tracking and medical records system. This is important for patient care and planning future events.
- Understand the scope of patient care, drugs, and resources available.
- Consider methods of patient transport (gurney, carrying, golf carts, ambulances, etc.).
- Insurance coverage: Most events are planned well ahead of time. In these situations, the Good Samaritan law is often void. Determine the level of insurance coverage needed and adjust accordingly.

Unique Events

Airline travel

- Most common complaints: Gastrointestinal, abdominal pain, and nausea/vomiting.
- Most serious complaints (aircraft can divert): Cardiac (MI), respiratory (PE), and neurological (stroke) complaints.
- Every airline has 24/7 physician consultation availability via

satellite phone or radio.

- A medical provider can request to increase cabin pressure or descend to a lower altitude.
- Unique environment: Dry air, lower partial pressure of oxygen, potential virulent airborne particles, potential chemical irritants, and venous stasis.

Wilderness Events

- Considerations: Extreme temperatures, possible severe weather, risk of providers becoming patients, remote access creates problems with extrication.

Cruise Ships

- Considerations: Isolated and dense population, often high-morbidity patients.
- Most common complaints: Dyspnea and injuries.

Ultradistance Events

- Considerations: Location (city, wilderness, etc.), hydration status, and electrolyte abnormalities.
- Develop a plan for rehydration and electrolyte replacement, including use of PO vs. IV and possible use of hypertonic saline.

Mass Casualty Incidents

Mass casualties are chaotic situations in which multiple casualties are present. They can occur at mass gatherings, workplaces, highways, or any other location in which multiple people are present. The needs of the patients usually outweigh the resources available. Consequently, the goal of care becomes the greatest good for the greatest number.

These challenges necessitate the use of a triage method to determine the order in which patients are addressed. Multiple triage methods can be used for mass casualties. A federally funded committee was appointed to evaluate the evidence pertaining to mass casualty triage and develop the Model Uniform Core Criteria, a set of requirements to ensure interoperability regardless of the triage system used. The resulting algorithm is called SALT: Sort, Assess, Lifesaving intervention, Transport. It is a nonproprietary triage scheme that meets Model Uniform Core Criteria and is used in some communities. It is important to understand what triage algorithm is used in your community.

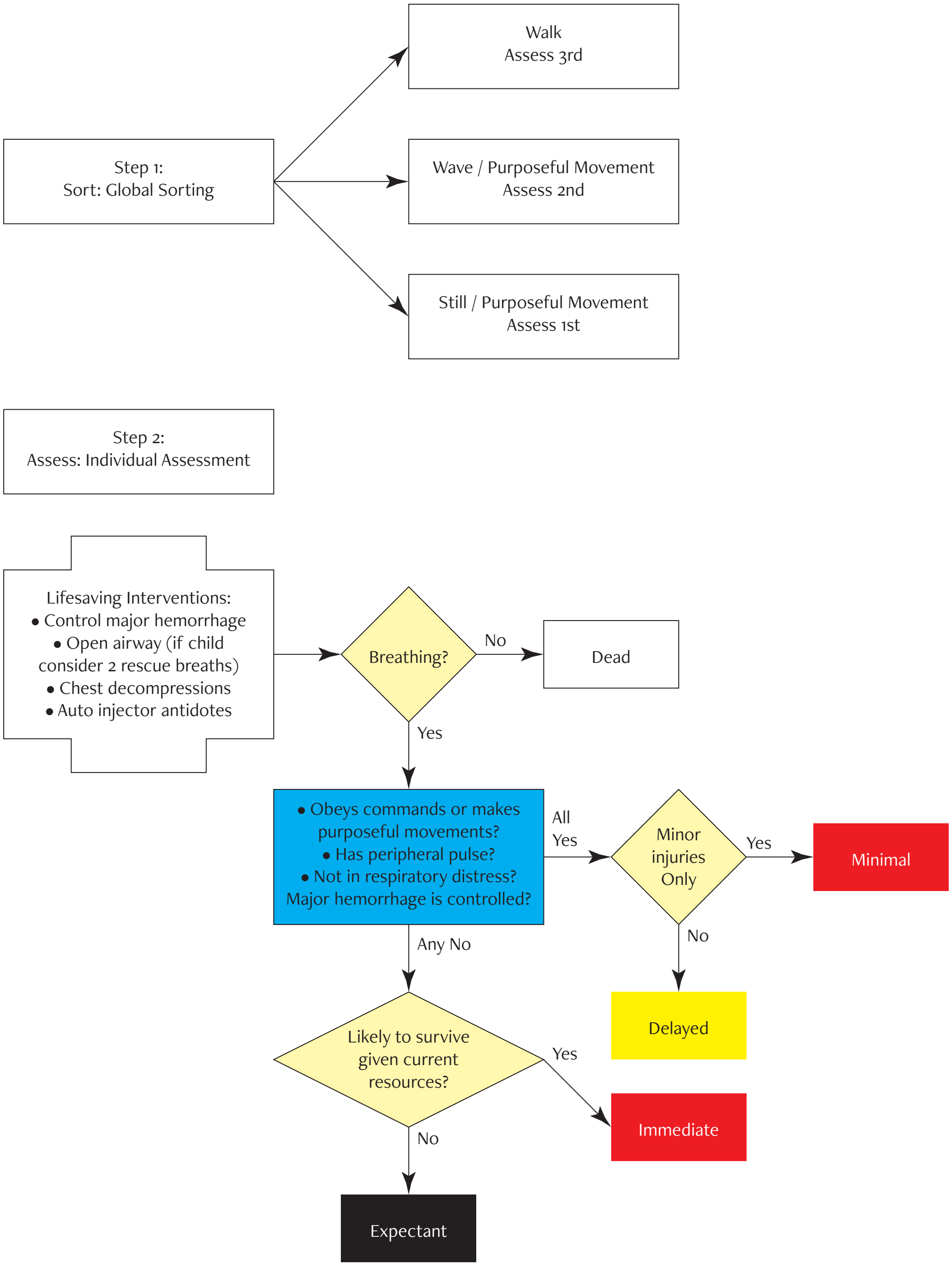
Global Sorting

1. Instruct those who can walk to move to a designated area. Assess last. They exhibit cerebral perfusion and essentially intact motor function.

2. Instruct those who can hear but cannot walk to wave. These patients exhibit cerebral perfusion but have some other

IMAGE

SALT



Adapted from: SALT mass casualty triage: concept endorsed by the American College of Emergency Physicians, American College of Surgeons Committee on Trauma, American Trauma Society, National Association of EMS Physicians, National Disaster Life Support Education Consortium, and State and Territorial Injury Prevention Directos Association. *Disaster Med Public Health Prep.* 2008:2(4):245-246.

injury or situation. Assess second.

3. Those who do not walk or wave need to be assessed first. They most likely have the most serious, time-sensitive injuries.

Assess

Patients are given a color corresponding to their need for treatment. A system will be in place to designate the color and record any intervention. This could range from commercially available cards to a marker on patient's head or skin.

TABLE 1.

Assessment

Category	Color	Definition	Key Points
Immediate	Red	"Life or Limb"	Does not obey commands No peripheral pulse Respiratory distress Uncontrolled hemorrhage
Delayed	Yellow	Stable but needs definitive care	Requires continual reassessment
Minimal	Green	"Walking wounded"	Often self-triaged
Expectant	Gray	Given resources, unlikely to survive	Initiate palliative interventions when resources are available
Dead	Black	Not breathing after lifesaving interventions	

**Note: these may be different depending on your local triage scheme*

Provide Lifesaving Interventions

- Performed simultaneously with assessment.
- Controlling hemorrhage (tourniquet, direct pressure, etc.).
- Needle thoracostomy for tension pneumothorax.
- Autoinjector medications.
- Two rescue breaths may be given to children due to higher incidence of respiratory-related arrest.
- Not recommended: Chest compressions, intubation, bag-valve-mask ventilation.
- If patient is not breathing in the field, s/he is effectively considered dead.

Transport

- Largely incident command dependent.
- Those transported first are those who have the highest likelihood of survival given more interventions.

Mistakes to Avoid

- **Considering triage complete:** Patients require reassessment.
- **Providing inappropriately complex care:** Keep decisions and interventions within the scope of time and resources.

- **Forgetting about the expectant patients:** Enact palliative measures (eg, pain control) as more resources become available.

Incident Command System

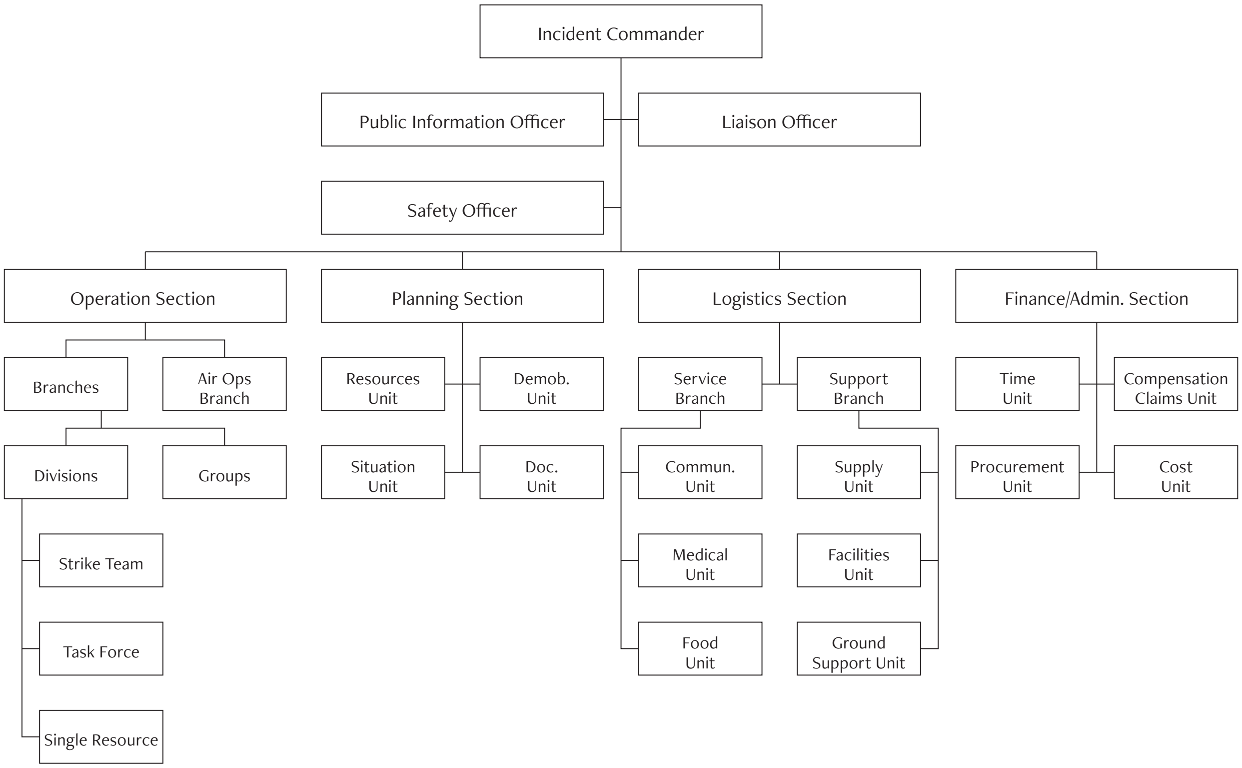
Incidents where resources are overwhelmed require many responders from many agencies. The management and integration of all resources is critical for a good outcome. In the United States the incident command system (ICS) provides this framework.

ICS Structure

- Flexible virtual organization to meet the needs of time-limited situations
- Task-determined architecture linked by information pathways
- Modular design allows expansion or contraction to integrate needs and assets
- Goals (in order of priority): life safety, incident stabilization, and property conservation
- Directed by an incident commander to whom all responsibilities belong until delegated.

FIGURE 1.

INCIDENT COMMAND STRUCTURE



Main principles of ICS

1. Unity of Command: Each person only answers to one superior.

2. Span of Control: Each person has only 3-7 constituents immediately answering to him or her.

Residents

- Function under the operations section within the medical branch.

- Avoid freelancing; do not change roles unless instructed by superior.

References

1. Lerner EB, Schwartz RB, Coule PL, et al. Mass casualty triage: An evaluation of the data and development of a proposed national guideline. *Disaster Med Public Health Prep*. 2008;2 Suppl1:S25-34.
2. Franaszek J. Medical care at mass gatherings. *Ann Emerg Med*. 1986;15(5):600-601.
3. Mass Gathering Medical Care. *Prehosp Emerg Care*. 2015;19(4)558.
4. ICS Resource Center. FEMA Emergency Management Institute. http://training.fema.gov/EMIWeb/IS/ICSResource/index.htm.

CHAPTER 7

Haz-Mat

Yuko Nakajima, MD
Anthony Tomassoni, MD, MS, FACEP, FACMT

The hazardous materials (haz-mat) category includes materials that are radioactive, flammable, explosive, corrosive, oxidizing, asphyxiating, bio-hazardous, toxic, pathogenic, or allergenic.

The aim of emergency personnel should be to make a chemical-specific identification while exercising caution to prevent exposure to any chemicals. Identifying the hazardous material and obtaining information on its physical characteristics and toxicity are vital steps to the responder's safety and effective management of the haz-mat incident.

If release is suspected:

1. Remain calm.
2. Put on personal protective equipment (PPE).
3. Reassure victims that assistance is on the way.
4. Wait for properly equipped help at a safe location (upwind, upstream).

Incident Objectives

- Secure perimeter and designate zones of operation.
- Identify and control agent.
- Rescue, decontaminate, triage/treat/transport affected individuals.
- Move uninvolved crowd/persons to safe zones.
- Stabilize the incident.
- Avoid secondary contamination.
- Secure evidence and crime scene.
- Protect against secondary attack.

Six primary clues to hazardous materials

Occupancy and Location – Obvious locations in the community that use and/or store hazardous materials include laboratories, factories, farms, paint supply outlets, construction sites, etc.

Container Shape – Haz-mat transport container specifications are regulated by the Department of Transport (DOT).

Markings/Colors - Marking scheme designed by National Fire Protection Association (NFPA 704M system) identifies hazard characteristics of materials at terminals and industrial sites (but does not provide product-specific information).

Placards/Labels - Hazard class wording or four-digit identification numbers, placards used when hazardous materials are stored in bulk (>1001 lbs), and labels identify smaller packages.

Shipping Papers - These are required to have a 24-hour emergency information phone number. Provides shipping name, hazard class, ID number, quantity, and may indicate if the material is waste or poison.

Senses – Odor, vapor clouds, dead animals/fish, fire, skin/eye irritation can signal the presence of hazardous materials. People can be biological detectors (coughing, choking, vomiting). Some chemicals can impair an individual's sense of smell (eg, hydrogen sulfide) and others have no odor/color/taste (eg, CO).

NFPA 704 Marking scheme (Fire Diamond)

This is the standard system for the identification of the hazards of materials for emergency response. (Figure)

Recognition of Common Toxidromes

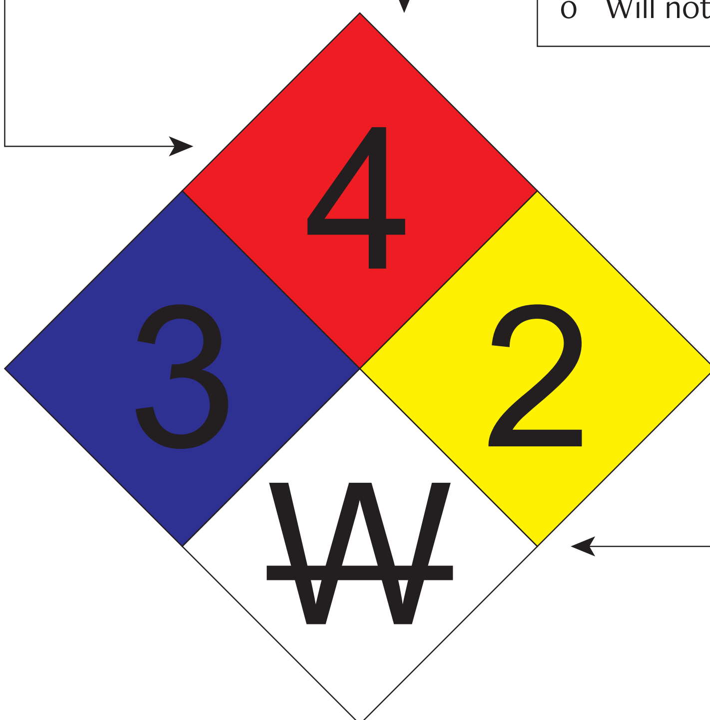
- constellation of clinical clues to identify the poison. Begin with vital signs and mental status, then add other autonomic indicators. (Table)

FIGURE

Fire Diamond

(BLUE)
HEALTH HAZARD
4 Deadly
3 Extreme danger
2 Hazardous
1 Slightly hazardous
0 Normal material

(RED)
FIRE HAZARD
Flash Points
4 Below 73°F
3 Below 100°F
2 Above 100°F not exceeding 200°F
1 Above 100°F
0 Will not burn



SPECIFIC HAZARD
Oxidizer . . . . OXY
Acid . . . . ACID
Alkaline . . . . ALK
Corrosive . . . . COR
Use NO WATER . . ~~W~~
Radioactive . . . . . .

(YELLOW)
REACTIVITY
Flash Points
4 May Detonate
3 Shock & Heat may detonate
2 Violent chemical change
0 Stable

TABLE

Common Toxidromes

Toxidromes	Symptoms	Typical toxins
SYMPATHOMIMETIC	Tachycardia, hypertension, hyperthermia, agitation (occasional psychosis), seizures, diaphoresis, bowel sounds often present (help to exclude anticholinergic syndrome)	Epinephrine, norepi, dopamine, amphetamines, cocaine, MAOIs, yohimbine, phenylpropanolamine, ephedrine, pseudoephedrine (caffeine, theophylline, PCP, LSD may be similar)
ANTICHOLINERGIC	"Red as a beet, dry as a bone. Mad as a hatter, hot as stone. Blind as a bat, bowel and bladder lose their tone; the heart runs alone."	Belladonna alkaloids (atropine, scopolamine, hyoscyamine), cyclic antidepressants, antihistamines, phenothiazines, some mushrooms
CHOLINERGIC Muscarinic	DUMBELS: Defecation, Urination, Miosis, Bradycardia/ Bronchorrhea/ Bronchospasm, Emesis, Lacrimation, Salivation/ Seizures	Organophosphate insecticides, "nerve gas," carbamates, some mushrooms, pilocarpine, methacholine

CHOLINERGIC Nicotinic	STUMBLED: Salivation, Tremor, Urination, Miosis, Bradycardia, Lacrimation, Emesis, Diarrhea. *Biphasic response: excitation followed by depression, tachycardia, bradycardia, hypertension, hypotension, coma, fasciculation, paralysis, seizures	Tobacco, nicotinic insecticides, nicotine patches/gum, coniine, lobelline, other alkaloids
NARCOTIC	CNS depression, miosis, hypoventilation, hypotension	Opiates/opioids

Treatment for Common Toxidromes	
SYMPATHOMIMETIC	Benzodiazepines
ANTICHOLINERGIC	Physostigmine (not recommended in prehospital setting)
CHOLINERGIC (Muscarinic)	Atropine, pralidoxime (not for carbamates)
CHOLINERGIC (Nicotinic)	Atropine, mainly supportive
NARCOTIC	Naloxone

Personal Protection Equipment (PPE)

Personal protection equipment (PPE) is used to isolate or shield individuals from chemical, physical, and biological hazards. The use of PPE itself creates significant worker hazards, such as heat stress, physical and psychological stress, and impaired vision, mobility, and communication. In general, the greater the level of PPE protection, the greater the associated risks. Personnel should not use PPE without adequate training (specific training is mandatory).

Level A protection: Fully encapsulated vapor-tight, chemical-resistant suit, chemical-resistant boots with steel toe and shank, chemical-resistant inner/outer gloves, coveralls, hard hat, self-contained breathing apparatus (SCBA).

Level B protection: Differs from Level A only in that it provides splash protection through use of chemical-resistant clothing.

Level C protection: Same degree of skin protection as Level B, but a lower level of respiratory protection.

Level D protection: Primarily a work uniform. No respiratory protection, minimal skin protection.

Respiratory Protection

There are 2 basic types of respirators: air-purifying and atmosphere-supplying. Atmosphere-supplying respirators include self-contained breathing apparatus (SCBA) and supplied-air respirators (SAR).

Air-Purifying Respirators (APRs)

Purifies ambient air by passing it through a filtering element before inhalation. The advantage is mobility; however, it requires sufficient oxygen (19.5%) since it depends on ambient air to function. APRs should not be used when substances with poor warning properties are involved or if the agent is unknown, or when the environmental levels of a substance exceed the capacity of the canisters. Powered air-purifying respirators (PAPRs) have the advantage of creating an improved seal, thus reducing the risk of inhalation injury. PAPRs come in masks or pullover hoods; men with beards can wear the hooded system but not the full facemask.

Atmosphere-Supplying Respirators

A self-contained breathing apparatus (SCBA) contains its own air supply, with a face piece connected by a hose to a compressed air source.

- A Supplied Air Respirator (SAR) depends on an air supply provided through a line linked to a distant air source. It allows personnel to work longer than SCBA, and it's less bulky than SCBA. The air source has to be within 300 ft.

Site Control

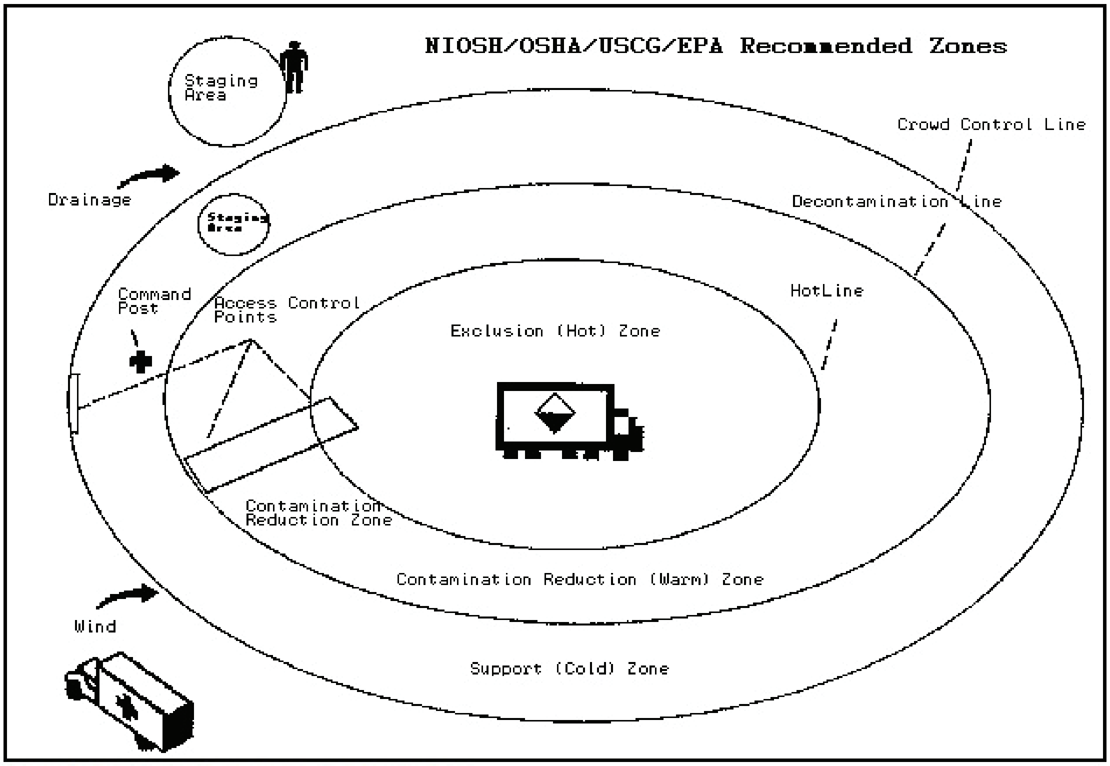
Hazardous materials incidents often attract large numbers of people and equipment. This complicates the task of minimizing risks to humans, property and environment. (Figure)

Exclusion (Hot) Zone: This "ground zero" perimeter should encompass all known or suspected hazardous materials contamination.

Contamination Reduction (Warm) Zone: A secondary zone of protection is determined by the length of the decontamina-

FIGURE

Haz-Mat Site Control



Source: Centers for Disease Control and Prevention

tion corridor, which contains all of the needed decontamination stations.

Support (Cold) Zone: The outermost zone is free of all hazardous materials contamination, including discarded protective clothing and respiratory equipment. **Command post and staging areas for necessary support equipment should be located in the support (cold) area, upwind and uphill of the exclusion (red) zone.*

Personnel decontamination method

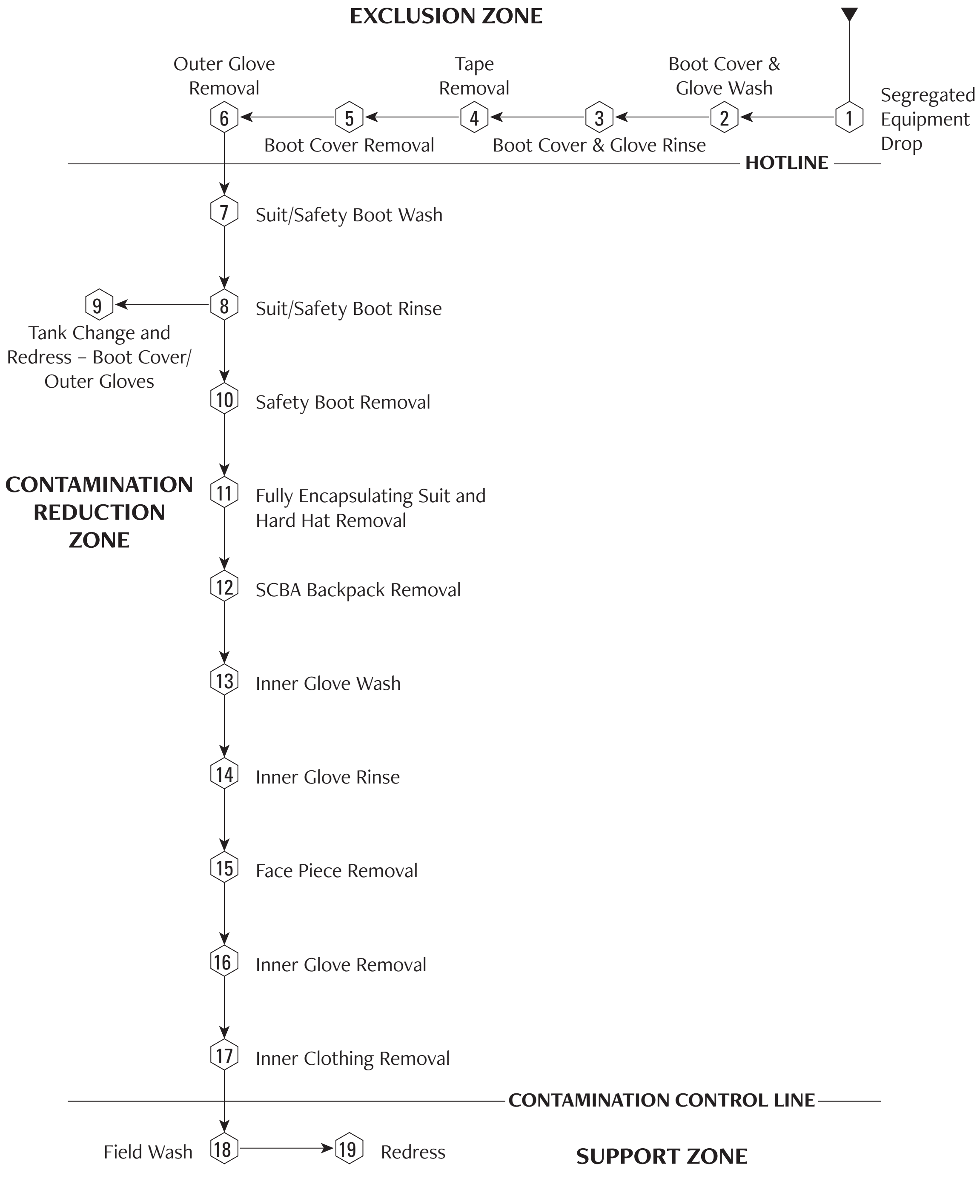
Be aware of telephone and computer-based information sources concerning hazardous materials. The regional Poison Control Center, Soldier and Biological Chemical Command (SBCCOM), and Centers for Disease Control and Prevention (CDC) can be contacted 24 hours a day to provide vital information on the medical management of hazardous material exposures. (Figure)

References

1. NIOSH Pocket Guide to Chemical Hazards. Centers for Disease Control and *Prevention.* http://www.cdc.gov/niosh/npg/.
2. Alibek K, Dashiell T, Dwyer A, et al. Jane's Chem-Bio Handbook. 3rd ed. Surrey, UK: Jane's Information Group; 2005.
3. USAMRIID's Medical Management of Biological Casualties Handbook. 4th ed. Fort Detrick, MD: U.S. Army Medical Research Institute of Infectious Diseases; 2001.
4. Medical Management of Chemical Casualties Handbook. 4th ed. Aberdeen Proving Ground, MD: USAMRICD Chemical Casualty Care Division; 2007.

FIGURE

Decontamination Procedures: Level A Protection



Source: U.S. Occupational Safety & Health Administration

CHAPTER 8

Urban Search & Rescue

Yuko Nakajima, MD
Anthony Tomassoni, MD, MS, FACEP, FACMT

Urban search and rescue (USAR) is the process of locating, extricating, and providing for the immediate medical treatment of casualties trapped in confined spaces due to natural disasters, structural collapse, transportation accidents, mines, and collapsed trenches.

Goals

The objective of USAR is to recover casualties in a manner that maximizes the chance of recovery to their previous state of health and to rescue the highest number of people in the shortest amount of time while minimizing the risk to the rescuers.

Challenges

In confined spaces, special techniques are required to evaluate and treat the entrapped victim before extrication. Scoop and run philosophy is not possible with the trapped or pinned individual. The most important medical intervention in this setting is the prevention of cardiac complications and renal failure due to crush injury or crush syndrome. Stabilize patients prior to extrication if the scene is safe.

Characteristics of Confined Space Medicine

Confined spaces offer limited access and egress, along with unfavorable environmental conditions. Temperature extremes make hypothermia and hypoglycemia common; IV fluids and oxygen should be warmed. Confined spaces also contribute to heat-related illness, particularly for rescuers (protective clothing, strenuous activity, confined space, limited fluid intake). Encourage breaks with liberal hydration.

Crush Injury/Crush Syndrome

The most dangerous time during a casualty is during the extrication phase when compressive forces are suddenly released. Prolonged, continuous pressure involving skeletal muscle mass results in muscle breakdown, and the subsequent release of muscle contents into the circulation results in renal failure and eventual cardiac arrest. Death can occur a few minutes after the casualty is freed. The deceptive feature of crush syndrome is that it does not develop until the limb is free from entrapment. Adverse effects do not occur until circulation is restored to muscles when the crushing object is lifted. Rehydration, rewarming, and bicarbonate must be started prior to the complete extrication. Anticipate large amounts of IV fluid (6-10L) in the immediate post-release period.

Pulmonary Concerns

Airway obstruction, particulate contamination, restriction of ventilation, inhalation injury, and blast lung are the main concerns. Crush injury to the chest can be fatal and is not a common cause of death in collapse casualties. Particles from building collapse may induce acute and chronic pulmonary toxicity, primarily with the inflammatory and fibrogenic effects, and by injury to the cellular defense mechanism of the lung.

Volume Concerns and Vascular Access

Trapped victims are subject to dehydration, hemorrhage, and third spacing. Early fluid administration is important to prevent delayed complications as the victim is freed from the rubble. Vascular access must be initiated as soon as possible.

Timing Is Everything

Urban search and rescue uses the concept of "the golden day." The chance of extricating a casualty alive drops dramatically after 24 hours. However, there are reports of casualties surviving after being entrapped for 6 days and longer. Efforts should not be delayed or abandoned after 24 hours.

- 30 minutes — 91.0% survive
- 1 day — 81.0% survive
- 2 days — 36.7% survive
- 3 days — 33.7% survive
- 4 days — 19.0% survive

- 5 days — 7.4% survive

FEMA (Federal Emergency Management Agency)

FEMA, an agency of the U.S. Department of Homeland Security, promotes an emergency response based on small, decentralized teams trained in areas of the National Disaster Medical System (NDMS), Urban Search and Rescue (USAR), Disaster Mortuary Operations Response Team (DMORT), Disaster Medical Assistance Team (DMAT), and Mobile Emergency Resource Support (MERS). If there is a disaster warranting USAR support, local emergency manager may request assistance from state or the state may request federal assistance. FEMA will deploy the three closest task forces within 6 hours of notification.

Task Forces

The team should be self-sufficient for a minimum of 72 hours before needing to resupply and should have a capability to operate for at least 10 days before personnel replacement is needed. The team is also responsible for bringing its own rescue equipment, support materials, and medical equipment.

Organization Chart

Task Force Leader - Blend the team into the incident command structure of the local authorities and other agencies for implementation of their tactical assignment.

Search Team - Locate casualties using canines, special protocols, and equipment.

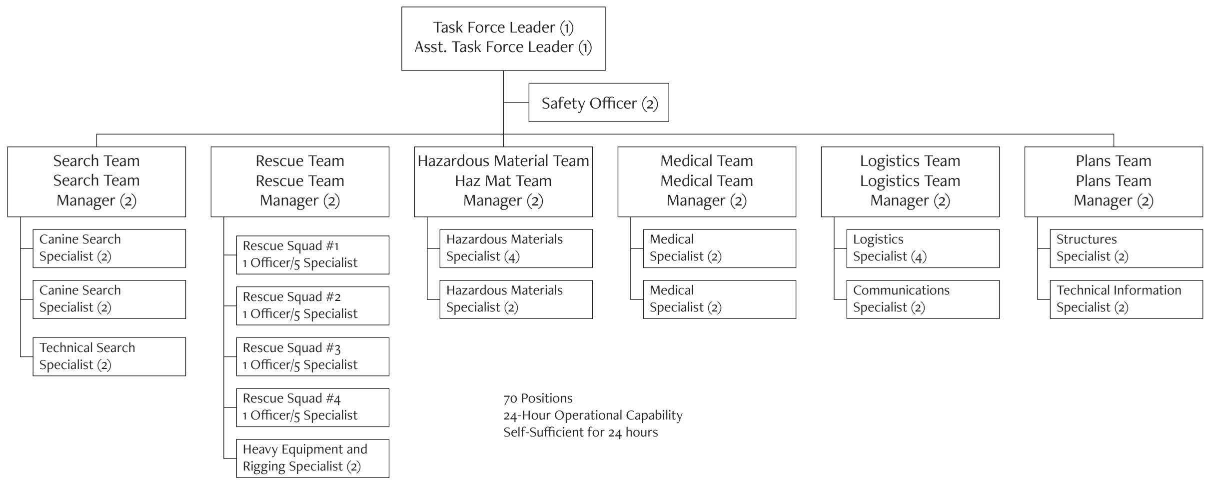
Rescue Team - Evaluate the collapsed structure, stabilize the structure, and extricate casualties.

Technical Team - Hazardous materials assessment, structural stabilization, advice, communications, liaison for the local system, and logistical management.

Medical Team - Provides sophisticated emergency medical care for a potentially prolonged period during a mission. Unlike traditional disaster field care, such as that provided under a disaster medical assistance team (DMAT), the USAR medical team is designed to deliver more sophisticated care to fewer patients. The team must be medically self-sufficient and must not rely on the local medical system for support.

FIGURE.

Organization Chart



Treatment Priorities

After the care of the task force is ensured, attention can be turned to entrapped casualties, search team canines, and the surrounding community. The USAR medical team will hand casualties over to local EMS agencies or DMAT at a designated location just outside the perimeter of the working rescue zone.

United States FEMA Markings

The structure triage, assessment, and marking system is designed to help identify, select, and prioritize the buildings with the highest probability of success with respect to finding and rescuing live victims. It is important that information related to building identification, conditions and hazards, and victim status be posted in a standardized fashion.

A 2x2 square box is outlined at any entrance accessible for entry into a compromised structure.

Aerosol spray cans (International orange color only) are used for the marking system.

International Search and Rescue Advisory Group (INSARAG)

INSARAG is a global network of disaster-prone and disaster-responding countries and organizations dedicated to USAR and operational field coordination. It aims to establish standards and classification for international USAR teams as well as methodology for international response coordination in the aftermath of earthquakes and collapsed structure disasters. The INSARAG Secretariat is located in the United Nations Office for the Coordination of Humanitarian Affairs (OCHA).

References

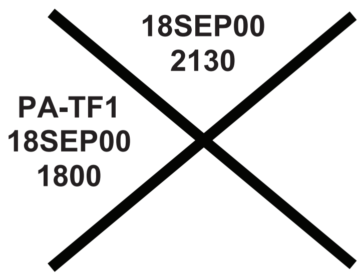
1. Goodman C, Hogan, D. Urban Search and Rescue. In: Hogan D, Burstein, J, eds. Disaster Medicine. Philadelphia: Lippincott Williams and Wilkins; 2002:112-122.
2. National Urban Search & Rescue Response System's Rescue Field Operations Guide. https://www.fema.gov/pdf/emergency/usr/usr_23_20080205_rog.pdf.

FIGURE.

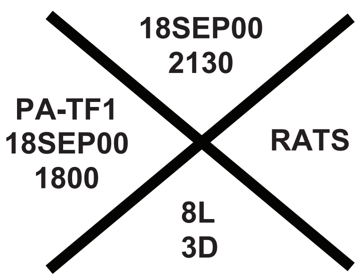
FEMA –Incomplete Search

FEMA Search Assessment Marking

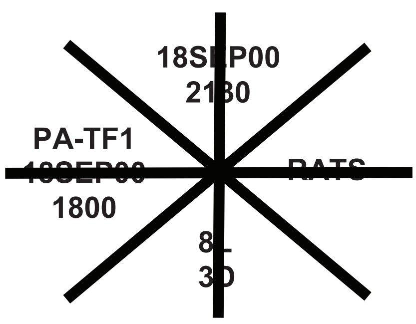
- Single slash upon entry into structure
- TF ID, date & entry time noted
- Indicates ongoing search



- Crossing slash upon exit
- Upon exit, date and time noted in top field
- Additional information placed in open areas of “X”



- Right - hazards
- Bottom - # of victims



- When new search completed, cross out previous, and complete new search assessment marking

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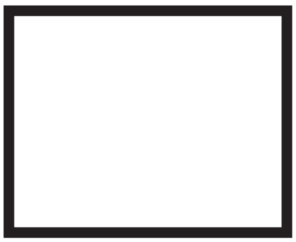
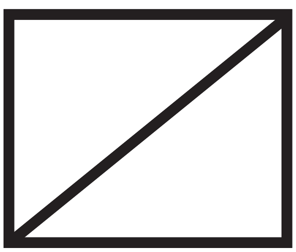
FIGURE.

FEMA – Structure/Hazards Marking

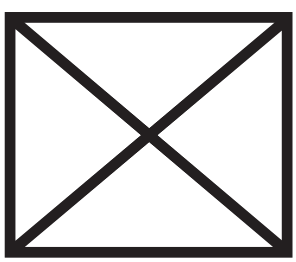
FEMA Structures/Hazards Marking



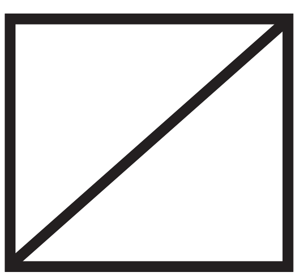
- 2x2ft (60x60cm)
- Structure relatively safe for US&R operations



- Structure significantly damaged
- Shoring/removal of hazards may be required



- Structure not safe for normal US&R operations
- Extensive safety measures must be taken before entry



28 JUN 03
NATURAL GAS
1432HRS
NE-TF1

- To right of box:
  - Date
  - Hazards
  - Time
  - TF ID

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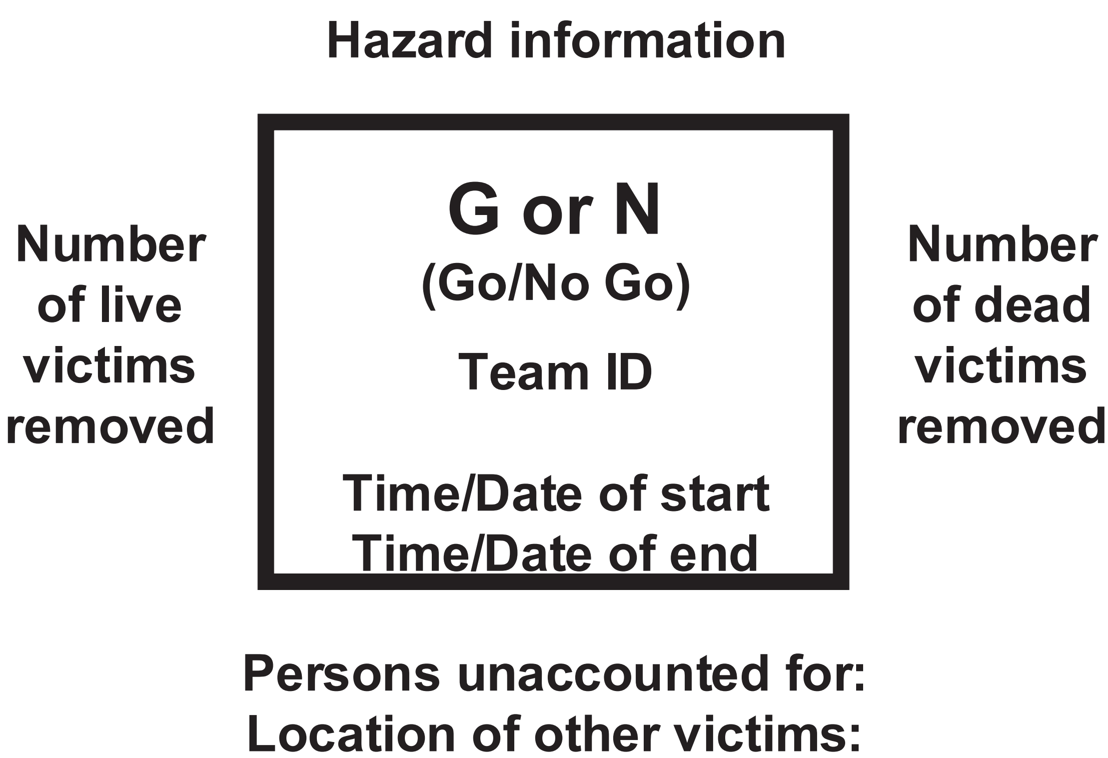
FIGURE.

INSARAG Structure Assessment Marking

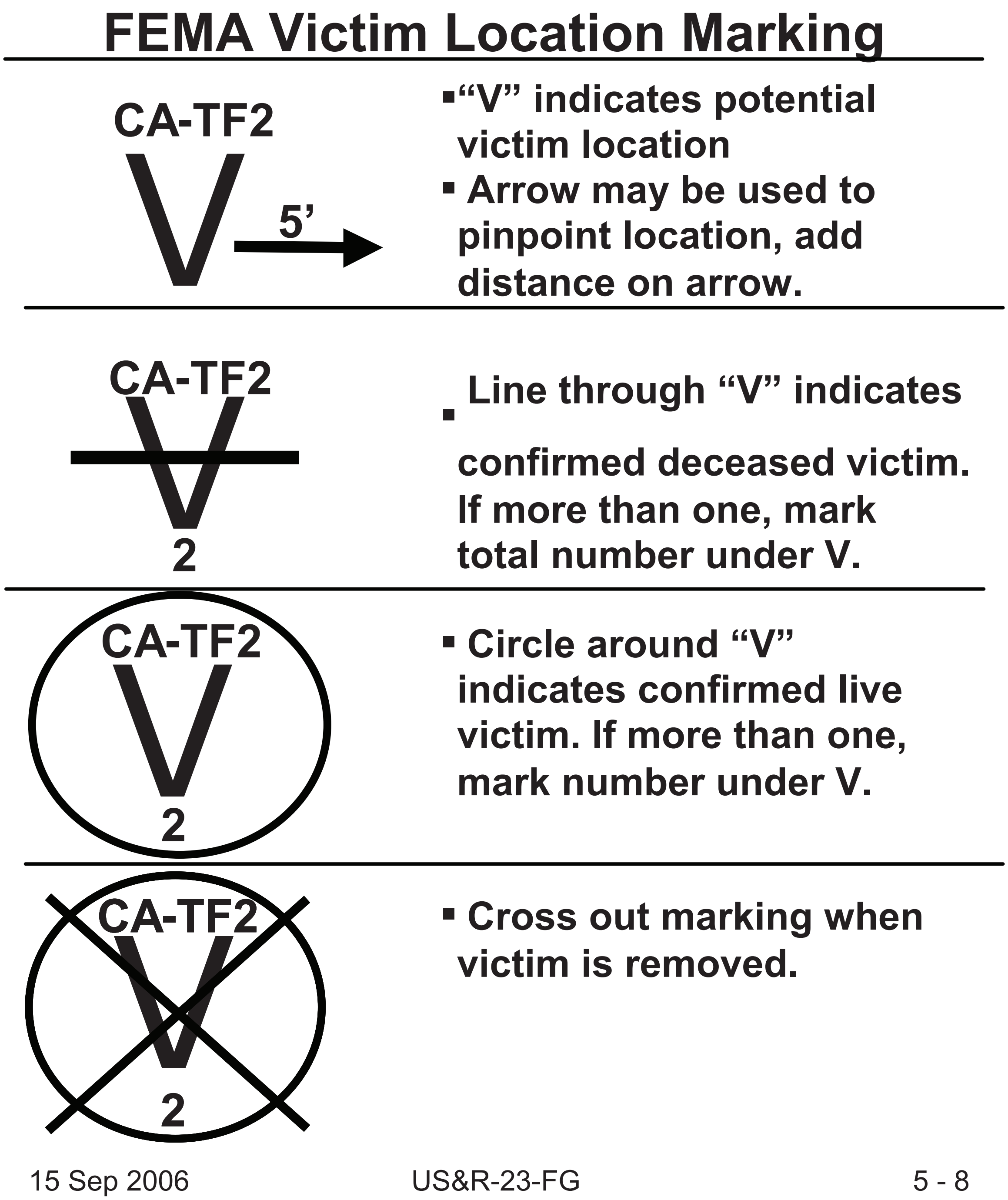
INSARAG Structure Assessment Marking



***When operation is completed, the box is circled.**

FIGURE.

FEMA Victim Location Marking



CHAPTER 9

Rural EMS

David R. Sutherland, MD, MS
Jenna M. B. White, MD

Providing emergency medical care outside of urban settings presents unique challenges. Agencies charged with this responsibility have developed means to meet this goal with limited resources. Two broad categories of non-urban EMS will be reviewed: rural EMS and wilderness EMS.

Rural EMS: While no specific definition exists for rural EMS, such agencies are faced with challenges regarding personnel staffing, limited medical training, and logistical issues.

Staffing models: Although the names vary, most rural EMS agencies use one of three staffing models.

1. **Volunteer:** All personnel within an agency are perpetually "on-call." Anyone available to respond does, often in personal vehicles. They are unpaid.

2. **Home call:** A subset of personnel is on call for a given shift. They must remain within a certain distance of the station in the event a call comes in. When a call is paged out, they

drive to the station and take the ambulance to the scene.

3. **In-vehicle call:** On-call providers remain with the ambulance for their shift and respond to calls as needed. This is essentially akin to urban EMS models.

Medical Training

- Time: Personnel for rural EMS agencies are almost universally providing this service as a second job or, more frequently, as volunteers. As such they cannot dedicate sufficient time to become trained to advanced levels, such as paramedic. Even meeting CME requirements for basic levels can be challenging.

- Number of providers: Rural communities are, by definition, sparsely populated and, as such, do not provide a large pool of potential providers. Many of these agencies are woefully understaffed and cannot respond to multiple calls simultaneously without aid.

- Retention: With time constraints, there typically is high turnover in these agencies. This increases burden on those leading the agency to recruit and train new staff.

- Clinical skills: Rural EMS providers have significantly lower call volumes and therefore have less exposure to critically ill patients. Therefore, their clinical skill proficiency for advanced procedures, such as ACLS and intubations, is in jeopardy unless the agency recognizes this gap and provides sufficient training.

Logistical Considerations

- Prolonged transport time: Some agencies have transport times in excess of 6 hours to reach definitive care. The "golden hour" is generally unachievable in rural EMS. This long patient contact time creates a need for ongoing assessments in addition to the usual "stabilize and transport" mantra.
- Aeromedical intercepts: For critical patients, rendezvousing with a helicopter or airplane to complete timely transport is routine. Typically the ground unit will proceed toward the hospital until intercepted by the air ambulance at a predetermined landing zone.
- Reciprocal aid: With limited personnel and ambulances, mutual aid agreements are often employed in an attempt to provide resources in the event of multiple, simultaneous calls or a disaster.
- Fire department: Because rural agencies are typically volunteer, fire department personnel may not be medically cross-trained like urban firefighters are. This can leave rural EMS providers without medical assistance on scene.
- Medical direction: Rural EMS medical directors may be

available on occasion for online medical direction. In some circumstances, the receiving hospital may serve to provide online medical control, but this may not be feasible if the call occurs outside of hospital radio or cellphone reception. The off-line protocols, or clinical guidelines, address the most commonly encountered scenarios.

Wilderness Medicine

This section of medicine is so broad it includes academic societies, numerous large textbooks, and post-residency fellowships. Commonly defined as an environment where definitive care is farther than 1 hour away, many rural response areas could technically be considered wilderness. In this context, we will only consider formal response agencies that an emergency medicine resident may encounter, a brief description of provider levels unique to this field, and the unusual considerations this practice environment creates.

While no specific training is government-mandated for wilderness response agencies, many employ training courses that provide medical personnel with skills unique to wilderness settings.

Types of Wilderness EMS Agencies

- **Search and Rescue (SAR):** These are generally law enforcement affiliated, with varying levels of medical competence, from first aid to paramedic. Frequently takes ambulance personnel into the field on medical calls to provide patient care while the SAR team coordinates the technical aspects of rescue.

- **Ski Patrol:** Skilled at winter rescues. Generally trained to the EMT-B level.
- **Park Service:** Varying levels of sophistication, with some services having large teams while others have a single ranger. Medical training also varies.
- **Police:** Often participate in the role of SAR. Most officers have first responder training but varying levels of comfort with treating patients.

Wilderness Provider Levels

- **Wilderness First Aid:** 1- to 2-day course on the basics of first aid. Unlike urban first aid, emphasis is not solely on "calling 911."
- **Wilderness First Responder:** Approximately 80-hour course covering a broad range of medical topics. Such responders can be very skilled if they use their training frequently. Otherwise, training fades quickly.
- **Wilderness EMT:** Weeklong course offered to EMTs to teach improvisation and how to function outside of an ambulance filled with medical tools.
- **Advanced Wilderness Life Support:** 3- to 5-day course

designed for medical professionals who want to learn how to provide care with limited diagnostic and treatment options. Typically, course consists of doctors, mid-levels, and some nurses.

Special Considerations

- **Limited resources:** Medical tools limited to what can be carried on one's back. Extra personnel may take a long time to get to the scene.
- **Extended scope of practice:** Medical directors will frequently create protocols for providers to act beyond their formal level of training if certain conditions exist. This is helpful when communication and resources are limited.
- **Extreme environments:** Shelter from elements is often not readily available. Working in these conditions will place rescuers at risk for becoming patients themselves and must be considered prior to exposing personnel.
- **Air support:** If available, air support can aid in extracting patients and avoiding long carrying of an injured patient. If the patient is not critical, the air ambulance can rendezvous with a ground unit for the remaining portion of the transport, which saves both money and resources.
- **Legal:** In the absence of well-defined provider roles, the legal implications of wilderness EMS are unclear, and standards of

care in wilderness settings have not been well-established. It is safest to assume most EMS laws will apply in wilderness situations, but do not place rescuers or the patient at risk merely to meet a law.

References

1. Shade BR, Rothenberg M, et al. Mosby's EMT-Intermediate Textbook. 2nd ed. Maryland Heights, MO: Mosby; 2002.2. Wilderness Medical Society. http://www.wms.org/.

CHAPTER 10

Nuclear Emergencies

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Types of Radiation Exposure

Radiation is the release of energy from atoms. It can be categorized as non-ionizing or ionizing.

- Non-Ionizing: Low intensity and low frequency waveforms, such as microwaves and heat.
- Ionizing radiation is composed of particles and high frequency waveforms with sufficient energy to remove electrons from atoms.
    - Alpha particle: 2 protons and 2 neutrons. High energy with low penetration. Travels only a few centimeters in air. Primary sources include uranium and plutonium. Main risk is inhalation injury or ingestion.
    - Beta particle: Travels several meters. Penetrates several centimeters into tissue. Potential sources include Carbon-14, Iodine-131, Radium-226, Cobalt-60, Selenium-75. Hazardous as an external or internal contaminant.

- Neutron particle: Variable energy and penetration. Major source from fission reactions, such as nuclear weapons and power plants.

- May be absorbed by metal devices.

- Waveforms: Electromagnetic energy, such as x-ray and gamma rays, emitted from the cell nucleus. High energy and high penetration of tissue. Gamma emitters include Cobalt-60, Cesium-137, and Iridium-192. Large doses of whole body exposure can cause acute radiation sickness.

Detection

EMS detection of radiation can be accomplished by:

- Portable instruments: "Geiger counter" is the most commonly used.

- Personnel dosimeters: Worn on the anterior thorax. These instruments should be provided to all staff working in a potentially contaminated field.

First responders must consider that, in the post-9/11 era, any bombing could potentially be a "dirty bomb."[3] In addition, responders should suspect potential radioactivity on any scene they see the trefoil, which is the international radiation symbol.[5]

En-Route Considerations

Responders should attempt to gather as much information as possible while traveling to an incident that could involve a radioactive substance. A checklist to help determine initial actions should be developed and made available to all EMS personnel. This checklist should include:[1]

- Type and nature of the incident
- Radioactive substance name if known
- Name and age of victims
- Signs and symptoms experienced by patients
- Injuries sustained by patients
- Routes of exposure
- Length of exposure

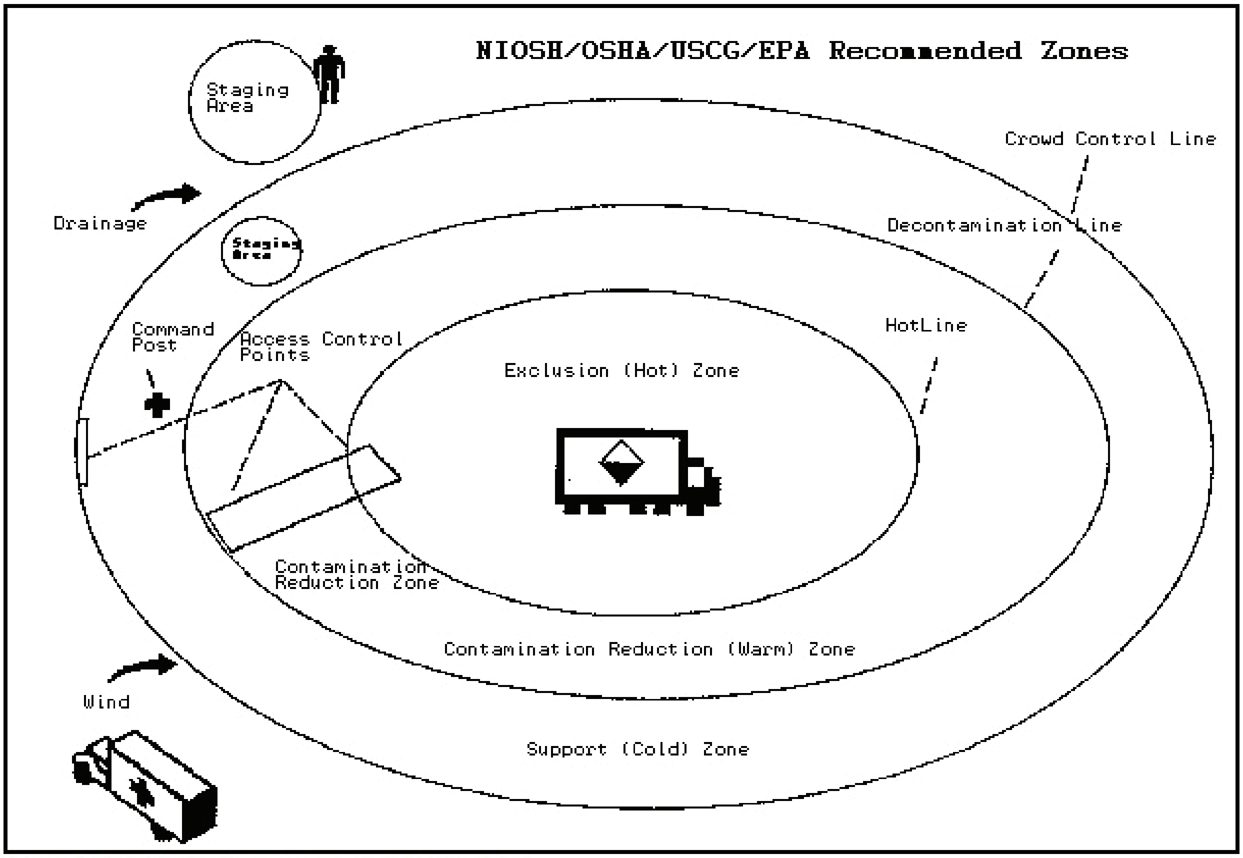
In addition, communication should be established with local authorities, particularly police and fire.

On Scene

In general, the ambulance should park upwind, uphill, and at a safe distance from a potential radioactive site.[1] Helicopters should not be used as the transport vehicle, because the draft wind can stir up radioactive particles. Scene safety takes priority in the emergency response to a radiologic event. The primary goal of first responders is to isolate the scene. NIOSH, OSHA, USCG, and EPA recommend dividing the incident area into 3 zones, establishing access control points, and delineating a contamination reduction corridor based on the military model.[1,2]

IMAGE

Haz-Mat Site Control



Source: Centers for Disease Control and Prevention

Exclusion (Hot) Zone: Encompasses all suspected hazardous material. The Gross Decontamination Phase and basic lifesaving measures such as airway and hemorrhage control occur in this zone.[1]

Contamination Reduction (Warm) Zone: A safe distance from hot zone; may still have some contamination and PPE is still worn. Definitive decontamination occurs in this zone.[1]

Support (Cold) Zone: Free of all hazardous contamination materials and includes the command and staging areas.

A quick scene assessment by trained personnel should determine the nature of personal protective equipment (PPE) required in the Hot Zone.

Decontamination

In general, decontamination requires:

- A safe area.
- A method for washing off contaminants; typically large volumes of tepid water.
- A means of containing the rinsed and contaminated material, such as marked double plastic bags.
- PPE for providers.
- Disposable or cleanable equipment.

- This includes gross patient contamination and secondary/definitive patient.

The Gross Decontamination phase includes the medical provider's primary assessment of ABCs, as well as the cutting away of clothing and jewelry once immediately life-threatening emergencies such as respiratory failure and hemorrhage are addressed. Open wounds should be cleaned and then covered with a water repellant dressing. The patient should then be rinsed with tepid water from head to toe.

Definitive Decontamination occurs in the "warm" zone and involves making the patient as clean as possible before transferring to the support zone and receiving facilities. Guidelines on duration of decontamination vary, but generally fall between 3-5 minutes, if not longer.[4,6] If resources or time constraints do not allow for thorough cleansing, the patient should be cocooned in a blanket or sheet prior to transfer.

The removal of clothing and shoes will reduce external contamination by 70-90%. Thorough washing with soap and water will provide over 95% decontamination.

Treatment

EMS treatment of the victim of radiation contamination or exposure is no different from standard patients, with the exception of the provider protecting oneself from contamination. The primary survey should be concurrent with the gross decontamination process. Secondary survey occurs when time allows. Treatment of airway emergencies follows standard protocols. Consider inhalation injury in anyone near blast sites. The majority of injuries resulting from a "dirty bomb" will be blast and thermal injuries.

Extensive burns require cleansing with saline or tepid water as part of decontamination. The patient should then be covered with sterile dressings and preferably transported to a burn center. If able, provide comfort with analgesics.[8]

Transport

No patient should be transported who, at a minimum, has not undergone gross decontamination.[1] Make sure to contact the receiving institution and ask for instructions for entering the hospital with a contaminated patient. The ambulance should park in a designated decontamination area. Upon release of the patient to the hospital, inquiries can be made as to where the ambulance can safely decontaminate and whether the institution has protocols and resources for this. The ambulance should not go back into service until deemed safely decontaminated by an adequately trained staff, such as a haz-mat team coordinator.

Resources

1. Agency for Toxic Substances and Disease Registry. Managing Hazardous Material Incidents (MHMI). Volumes 1, 2 , and 3. Agency for Toxic Substances and Disease Registry (ATSDR). 2001. Atlanta, GA: U.S. Department of Health and Human Services, Public Health Service

2. Brennan R, Waeckerle J, Sharp T, et al. Chemical warfare agents: emergency medical and emergency public health issues. *Ann Emerg Med*. 1999;34(2):191-204.

3. Broad W, Engelberg S, Glanz J. A Nation Challenged: The Threats; Assessing Risks, Chemical, Biological Even Nuclear. *The New York Times*; November 1, 2001.

4. Burgess JL, Kirk M, Borron SW, et al. Emergency department hazardous materials protocol for contaminated patients. A*nn Emerg Med*. 1999;34(2):205-212.

5. The Emergency Response Guidebook. A Guidebook for First Responders During the Initial Phase of a Dangerous Goods/Hazardous Materials Transportation Incident. 2012.

6. Houston M, Hendrickson RG. Decontamination. *Crit Care Clin*. 2005;21(4):653-672.

7. Radiation Emergency Assistance Center/Training Site (REAC/TS). http://www.orau.gov/reacts/default.htm

8. Skorga P, Persell DJ, Arangie P, et al. Caring for Victims of Nuclear and Radiological Terrorism. *The Nurse Practitioner*. 2003;28(2):25-41.

CHAPTER 11

Tactical EMS

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Tactical medicine comprises out-of-hospital medical services and supports for civilian law enforcement operations, typically SWAT operations.

What Does a SWAT Team Do?

SWAT (Special Weapons and Tactics) teams are law enforcement units with specialized training suitable for high-risk assignments. They can be local, state, or federal. Occasionally, these teams may be called something other than SWAT, like Special Response Teams (SRT).

Assignments frequently include:

- High-risk warrant service
- Active shooter response
- Barricaded suspects
- Hostage situations
- Clandestine drug lab interdiction

- Domestic terrorism
- Riots or civil unrest

Common Terms in the Tactical Environment

Cold zone: Outer-most perimeter of a tactical scene where risk is lowest.

Warm zone: Moderate risk area of the tactical scene where medical decision-making is most influenced by the dynamics of the tactical scene.

Hot zone: Inner perimeter of the tactical scene where risk is highest (ie, area of active fire).

Breach: To open or port a structure by force, usually with a tool.

Entry: The act of entering a structure with the intent to neutralize a known threat and/or clear the structure of additional or unknown threats.

Cover: Any structure on the tactical scene suitable to protect one from danger; not to be confused with "concealment."

Concealment: The state of being out of the visual field of the threat; not to be confused with "cover."

Operator: A law enforcement officer (LEO) who is a SWAT team member.

Stack: The term used for the entry team, based on its formation.

What is the role of the Tactical Medical Provider (TMP)?

TMPs can be paramedicine professionals, nurses, physician assistants, or physicians. Sometimes, a TMP is a sworn law enforcement officer with a medical background. The role of the TMP includes, but is not limited to:

- Providing team health and preventive care.
- Performing medical pre-planning for tactical operation.
- Attending to injury or illness during training and operations.
- Self-aid/buddy aid education for LEOs.
- Medical evaluation of a suspect prior to incarceration.
- Acting as liaison between the tactical team and medical community.

Challenges of the Tactical Environment

The tactical scene differs from the conventional pre-hospital environment because of the challenges presented. Frequent and focused training optimizes the ability of TMPs to work in this environment. Challenges include:

- Presence of an active, unpredictable threat to safety.

- Low light conditions.
- Sound impediments.
- Restrictive, bulky nature of protective gear.
- Chemical munitions.
- Limited field resources.
- Extraction and evacuation.
- Logistics of sustained operations.
- Preservation of evidence.

Medical Threat Assessment

The medical threat assessment (MTA) is the cornerstone of tactical medical support. It is the method by which the TMPs collect and document information for the medical pre-planning of an operation. This information is to be shared with the tactical commander for consideration when planning an operation. At a minimum, the MTA document should attempt to include the following information:

- Type of operation.
- Number of operators.
- Number of civilians and suspects on scene, and any pre-existing conditions they may have.

- Nearest ED, trauma center, and burn center.
- Any public works or other obstacle that would impede transport to definitive care.
- Nearest landing zone for air medical transport.
- Canine threats on scene.
- Emergency veterinary care.
- Fresh water source on scene.
- Weather and environmental conditions.

On-Scene

For tactical operations, the positioning and movement of TMPs are at the discretion of the tactical commander and can vary widely from team to team. Some TMPs will line up in the "stack" and make entry with operators. Others may remain in the "warm zone" behind hard cover or in the "cold zone." Safety is paramount.

PPE for the TMP:

- Body armor and ballistic helmet
- Eye protection
- Ear protection (unless it interferes with communication)
- Knee pads

- Medical PPE
- Air-purifying respirator (APR)
- Hydration system

Medical Care in the Tactical Environment

The medical treatment paradigms for civilian tactical operations are extrapolated from military medicine models. Based on military data, the 3 most common causes of preventable battlefield death are:

1. Extremity hemorrhage.
2. Tension pneumothorax.
3. Airway obstruction.

Tactical Combat Casualty Care (TCCC) is the military model for battlefield trauma care and is the most commonly used model for the civilian tactical environment. The 3 phases of care under TCCC are:

1. **Care Under Fire:** The phase of care rendered under hostile fire or while the threat is still active. Depending on the structure of the tactical team or the dynamics of the scene, the first responder may be an operator, and medical equipment may be limited to the contents of the operator's individual first aid kit (IFAK).

a. Contrary to conventional civilian trauma treatment models, emphasis is placed on hemorrhage control before airway management. The MARCH acronym is frequently used:

M — Massive hemorrhage
A — Airway
R — Respiration
C — Circulation
H — Head injury/hypothermia

2. **Tactical Field Care:** Care rendered when the first responder is no longer under hostile fire. It may also refer to care for the injured on a scene in the absence of antecedent hostile fire. Care may be more detailed and comprehensive, but is still limited by conditions and equipment. Multiple casualties should be triaged accordingly. Delay to definitive care should be minimized.

3. **Tactical Evacuation Care:** Care rendered once the casualty is en route to definitive care. Additional medical equipment and personnel may be present, but conditions are still a limitation.

Medical Equipment

Tactical medical kits vary based on the level of the provider, medical protocols, and practice environment. Many teams employ a "modular" system, where the medical kit is organized based on convenience, type of operation, length of operation, and other considerations. Though an exhaustive list of kit contents and formulary medications are beyond the scope of this reference, all kits should include the basic equipment necessary to address the 3 most common causes of preventable battlefield death. This includes:

- Tourniquets
- Compression bandages
- Nitrile gloves
- Gauze
- Nasopharyngeal airway
- Chest seals
- Large bore needles
- Shears

Resources

Campbell JE, et al. *Tactical Medicine Essentials.* Sudbury, MA: Jones & Bartlett Learning, 2012.

Schwartz, Richard B., John G. McManus, and Raymond E. Swienton. *Tactical Emergency Medicine.* Philadelphia: Wolters Kluwer/Lippincott Williams & Wilkins, 2008.

CHAPTER 12

Flight: Air Transport Physiology and Problems to Consider Along the Way

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Transporting patients via air has become a way of doing business, especially to tertiary referral centers from rural medical centers. This resource has great utility in critical times. Yet it also presents numerous challenges, thanks to basic laws of physics. In alleviating the dangers associated with air transport, it is imperative that all EMS providers associated with transport as well as physicians at the receiving center have a basic understanding of this physiology.

Boyle's Law: Gases expand with increasing altitude as barometric pressure decreases. The inverse applies on the descent.

Transport considerations: Altitude becomes an important consideration in an unpressurized aircraft, such as a helicopter. At altitudes where most helicopters fly, gas expansion is roughly 10-15%. In mountainous regions where helicopters may fly up to 8000 feet above sea level, gas expansion may be 30%. This may affect IV flow rates, ET cuff expansion, and body cavities such as the intestines, middle ear, sinuses, and fascial compartments.

Dalton's Law: As altitude increases, gases expand and the available oxygen decreases.

- At 10,000 feet, atmospheric pressure is 525 mmHg compared to 760 mmHg at sea level, while FiO_2 remains 21%. However, the partial pressure of oxygen has decreased to 110 mmHg. This becomes important as a pressure differential is required to cross from the alveoli into the bloodstream.

Medical consideration: This affects oxygen delivery to the body. Newborns and neonates are more likely to develop hypoxia, as a newborn's alveolar-arterial difference is roughly 25 mmHg compared to 10 mmHg in adults. As altitude increases, oxygen delivery decreases.

Transport considerations: As altitude increases and pressure decreases, gas expansion causes available oxygen to decrease. Therefore, someone with an SpO_2 of 92% at sea level may desaturate to 80% at altitude, even in a cabin pressurized to 12,000 feet.

Henry's Law: This pertains to solubility of gases within a liquid.

The partial pressure of gases and the solubility of the gas determine the amount of gas that will dissolve into liquid. Decreasing pressures at higher altitudes allows for gases to come out of solution, such as blood, into tissues.

Medical considerations: Decompression sickness or the bends and decreasing oxygenation at altitude. Trapped gas in tissue being released or evolved gas in blood being released. The most common joints affected are the shoulders and elbows in recreational divers. In technical divers and aviators, the hips and knees are most affected.

The *chokes* are caused by gas embolization, mimic a PE, and can lead to cardiovascular collapse. Subcutaneous emphysema is another decompression sickness.

Transport considerations: Unless a patient has been exposed to compressed gas within 24 hours, such as SCUBA diving, transport is rarely a problem under 25,000 feet. If a diver requires transport, stay below 8,000 feet, as this is equivalent to a non-diver flying above 40,000 feet in an unpressurized aircraft. Treatment for all patients is 100% oxygen and rapid descent.

Charles' Law: At constant pressure, the volume of gases is proportional. As temperature rises, molecules move faster and volume increases.

Medical considerations: Hypoxia and compartment syndrome

Transport considerations: Flight during the winter or middle of summer affects expanding and contracting structures, which rely on the rigidity of the structure containing the gas.

Real Stresses of Flight and Transport

The most common and worrisome problem in air medical transport is hypoxia, which can go undetected. There are four physiologic classifications of hypoxia.

Hypoxic Hypoxia (Altitude): Stages include indifferent (90-98% SpO_2), compensatory (80-89%), disturbance (70-79%), and critical (60-69%). This results in inadequate gas exchange at the alveolar-capillary membrane. Without compensatory mechanisms, this is usually encountered above 10,000 feet.

Oxygen Adjustment Equation: (FiO_2 x BP_1) / BP_2 = FiO_2 required

BP_1 = current barometric pressure

BP_2 = altitude or destination barometric pressure

TABLE

Symptoms based on stage

Stages	Indifferent	Compensatory	Disturbance	Critical
Altitude in thousands of feet	0-10	10-15	15-20	20-25
Symptoms	Decreased night vision, blurred vision, tunnel vision	Drowsiness, poor judgment, impaired coordination and efficiency, hyperventilation, headache, fatigue, numbness, tingling, air hunger, apprehension	Impaired flight control, handwriting, speech, vision, intellectual function and judgment, decreased coordination, memory, and sensation to pain, belligerence, euphoria	Circulatory and central nervous system failure, convulsions, cardiovascular collapse, death

• Causes: Decreased partial pressure of O2 in inspired air, airway obstruction, and V/Q defects

• Prevention: Ensure oxygen delivery to maintain PaO2 between 60 and 100 mmHg.

Device	Liters/Minute	% IO2
Nasal Cannula	1	24
Nasal Cannula	2	28
Nasal Cannula	3	32
Nasal Cannula	4	36
Nasal Cannula	6	44
Simple Mask	5-6	40
Simple Mask	6-7	50
Simple Mask	7-8	60
Partial Nonrebreather Mask	7	70
Partial Nonrebreather Mask	8	80
Partial Nonrebreather Mask	10	>90
• Limit time at altitude		
• Use supplemental oxygen and PEEP or NIPPV		
• Pressurize cabin and fly at lower altitudes with a pressurized cabin to approach that of sea level		

Barometric Stress: Trapped gas (Boyle's Law) and evolved gas (Henry's Law) disorders. Free gas in body cavities expands, and if it cannot escape, positive pressure develops barotrauma.

Organ systems affected

- **GI tract:** At constant temperature and altitude, the volume of wet gas is greater than dry gas due to water vapor. 1L of wet gas in the stomach and intestines may rapidly expand and cause severe pain, tachycardia, hypotension, syncope, and interfere with breathing. Expel gas by whatever means necessary via NG/OG.

- **Respiratory:** Pneumothorax increasing to tension pneumothorax. Unclamp catheters and chest tubes, perform thoracentesis, and descend to lower altitude.

- **Barobariatrauma:** Complication of barometric changes in obesity. Adipose tissue contains a high concentration of nitrogen that may be released into the blood stream, as well as a large amount of lipids that may cause fat emboli. Observe these patients for severe dyspnea, chest pain, petechia, pallor, and tachycardia. Placing an obese patient on 100% oxygen for pre-oxygenation prior to transport will help reduce the risk of barotraumas by roughly 50%.

- **Barotitis media:** Middle ear squeeze as equalization occurs may cause pain, vertigo, nausea, ear drum perforation, bleeding, or hearing loss. Equalization occurs by slow descent (500 feet/minute), yawning, swallowing, valsalva, Frenzel maneuver, or vasoconstricting nasal spray. Barosinusitis and barodentalgia are similar in physiology and treatment.

- **Pregnancy:** Because fetal hemoglobin is more saturated at lower PaO_2, fetal considerations for transport are less of a concern and maternal care and oxygenation should be the primary goal, as they may decompensate much faster at higher altitudes.

Thermal Stress: Thermal stress is the body's physiologic response to its environment, as the body is either dissipating heat to its environment to cool itself or creating heat by using energy. In all cases, the body is exchanging energy. The major concern of thermal stress is causing hypothermia and coagulopathy in patients moving toward the, "Lethal Triad," defined as hypothermia, acidosis, and coagulopathy. Factors contributing are ambient temperature, exposure time, cabin air circulation, litter position, and hot loading/unloading.

Cold physiologic effects include shivering, vasoconstriction, increased metabolic rate, myoclonic tensing, hypothermia, and coagulopathy.

G-Forces: Gravitational forces are acted on the patient during ascent, descent, and banking which may affect blood pooling and cause stagnant hypoxia. Positive "Gs" will move blood from the head toward the feet causing increased intravascular pressures, hypoxia, G-LOC (G force induced loss of consciousness), and blackouts. Negative "Gs" will cause blood pressure to rise in the head causing "redout," headaches, and increasing ICP.

Noise: Provide your patient and yourself with hearing protection as even non-hazardous noise may become hazardous with prolonged exposure. Hazardous noise may cause fatigue and headache. Noise also inhibits your ability as a care provider to properly monitor the patient.

Vibration: Little can be done to decrease vibration in transport, but precaution should be taken. Vibrations may interfere with patient assessment, invasive and noninvasive monitoring, and pacemakers. Effects include motion sickness, blurred vision, increasing heart and respiratory rates, metabolic rates, pain, irritability, fatigue, and thermal regulation. In a hypothermic patient, vibration may worsen the patient's condition. In a hyperthermic patient, vibration may cause vasoconstriction, delaying the body's ability to cool itself. Ensure the patient and crew is properly restrained and place padding on any part of the frame that may contact the patient to combat effects of vibration.

Third-spacing: This is primarily an effect seen during long distance transports where decreasing barometric pressure may cause leakage of fluid from intravascular spaces. This is further aggravated by temperature changes, vibration, and G-forces.

Humidity deficit: Water vapor in the air decreases as altitude increases. After 2 hours of flight, less than 5% of relative humidity remains in air circulation. Physiologic effects include respiratory membrane inflammation, decreased efficiency of gas exchange, desiccation, hypoxia, increasing BMR, and oxygen demand. Monitor high-risk patients such as burn, ventilator, and pre-existing dehydration patients closely. Maintain fluid replacement and humidified oxygen as needed.

References

1. Blumen IJ, et al. Principles and Direction of Air Medical Transport. Air Medical Physician Association. 2006.
2. Aeromedical Training For Flight Personnel: Altitude Physiology. Training Circular. Department of the Army. 2000.
3. Critical Care in the Air. U.S. Air Force Critical Care Air Transport Team.
4. Aeromedical Training. FM 3-04-301. U.S. Air Force Critical Care Air Transport Team Training Document.
5. Capt John Michael Fowler. Flight Physiology. CCAT instructor.

CHAPTER 13

Fire Ground Operations

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The fire ground is an inherently dangerous environment, and although seemingly chaotic, there is a surprising amount of organization to a fire scene. Much of the organization is standard across the fire service, while some is specific to the type of fire being fought.

Fire Operations

Incident Command System (ICS): The fire service follows the FEMA ICS structure when on calls. This system is adaptable for large and small incidents. The Incident Commander (IC) typically is the most senior officer on scene.

Chain of Command

- **Chief:** The overall commander of the fire department.
- **Assistant or Deputy Chief:** Helps the chief with administrative duties.
- **Battalion Chief:** Tactical commander of several stations.

- **Captain:** Commander of a station and apparatus.
- **Lieutenant:** Not present in many departments; often in command of a specific apparatus within a company if multiple apparatus are at one station.
- **Firefighter:** The "rank and file." Specific operations roles may be subdivided.

- **Personnel Accountability System (PAS):** A means of tracking who is on scene and where they are. This is achieved by each responder placing a nameplate or tag on a larger tag for their apparatus, which is given to the IC when checking in at a scene. Some departments use an electronic version of PAS. (Table)

Fire Apparatus

The engineer or driver of the apparatus is responsible for that vehicle and everything it carries. Nobody takes equipment from the fire apparatus without being told to do so and without informing the engineer.

- Engine (aka pumper): Pumps the water and carries hose
- Truck (aka ladder): Carries ladders and rescue gear
- Combination: Apparatus that combine engine and truck functions
- Brush: Wildland apparatus

TABLE

Fire Ground Operations

Command: Defines the incident goals and operational period objectives; includes an Incident Commander, Safety Officer, Public Information Officer, Senior Liaison, Senior Advisers

- **Operations:** Establishes strategy (approach methodology, etc.) and specific tactics (actions) to accomplish the goals and objectives set by Command; Coordinates and executes strategy and tactics to achieve response objectives

- **Logistics:** Supports Command and Operations in their use of personnel, supplies, and equipment; Performs technical activities required to maintain the function of operational facilities and processes

- **Admin/Finance:** Supports Command and Operations with administrative issues as well as tracking and processing incident expenses; Includes such issues as licensure requirements, regulatory compliance, and financial accounting

- **Planning:** Coordinates support activities for incident planning as well as contingency, long-range, and demobilization planning; Supports Command and Operations in processing incident information; Coordinates information activities across the response system

- Tanker: Large water tank apparatus used for scenes with limited water supply
- Utility: Contains equipment for support operations, such as generators, lighting, and extra SCBA bottles
- Heavy Rescue: Carries equipment for heavy technical rescue like trench, high-angle, vehicle extrication, and confined space
- Haz-mat: Carries equipment for containment and decontamination of hazardous material scenes

Helmet Color Coding

Helmet color coding aids in rapid identification of roles on a scene. Many departments use specific helmets for certain personnel.

- White: Chief
- Red: Captain
- Others: Departments may decide to code the engineers, firefighters, paramedics, and support personnel with different colors, including yellow, black, blue, and green

Structure Fire

- Sides of building: The street side (front) of a building is referred to as the A or alpha side. Subsequent sides are named in clockwise order around the building; B (bravo), C (charlie), D (delta).

- Hose safety: Use caution when standing near hoselines. As water is flowing into a hose, or being charged, they can move rapidly and cause injury.
- Teams: Depending on the nature of the call, various tactical teams may be formed.
  - Suppression: Primarily hose teams; can be interior or exterior.
  - Ventilation: Remove heat and smoke by using fans or cutting holes in the roof.
  - RIC/RIT: Rapid Intervention Crew/Team is charged with being ready to rescue downed firefighters at all times.
- Collapse zones: Standard "safe distance" from a building prone to collapse; 1½ times building height.

Wildland Fire

- Air Support
  - Planes are used to drop retardant in front of an advancing fire line. Some firefighters parachute into remote locations.
  - Helicopters are used to drop water on hotspots and crews in strategic locations.

- Line Crew: Firefighters use hand tools and machinery to cut fire lines or breaks in fuel to slow or stop fire spread. They may also light smaller, controlled fires called back burns to remove fuel prior to the main fire reaching critical structures.

- Operational zone: Sectors are named using letters to track where resources are deployed and fire progresses.

Medical Considerations

- Heat exposure: Temperatures inside homes can reach above 1000 degrees Fahrenheit. Limiting exposure to this heat, as well as effective means of cooling firefighters, is essential.

- Dehydration: Hard work in heavy gear leads rapidly to dehydration and worsens risk of heat illness.

- Hypothermia: Fires that occur in the winter create risk of hypothermia as firefighters leave a building wet and warm, and subsequently cool rapidly.

- Cardiovascular disease: This is still the leading cause of death among firefighters. Some are relatively sedentary until placed on the fireground, where they strenuously exert themselves.

Other Fireground Terms

- Company: A crew under a Captain’s command

- Platoon: Comprised of multiple companies under a Battalion Chief’s command

- LDH: Large Diameter Hose; Hose greater than 3 inches in diameter typically used to supply fire engines
- SCBA: Self Contained Breathing Apparatus; a firefighter's air supply. Typically contains 30 to 45 minutes of air.
- PASS: Personal Alert Safety System; a device that alerts when a firefighter is motionless for a period of time or when air is low in the SCBA to aid the RIC/RIT in locating the downed firefighter quickly.
- Turnout or Bunker gear: A firefighter's personal protective equipment. Protects from both thermal injury during firefighting operations and contact injury from debris during extrication or other rescue operations.
- Shift: Most departments are staffed by three rotating shifts of firefighters—A, B, and C. Each shift is often referred to as a Platoon.
- Bay: A garage at the station where fire apparatus are kept
- Fire Classes
  - Class A—Ordinary Combustibles (wood, paper, cloth, etc.)
  - Class B—Liquids and Gases
  - Class C—Energized electrical equipment
  - Class D—Combustible metals

- Foam: Mixture of water and soap-like chemicals to cool fuel more effectively by decreasing water surface tension to improve penetration into fuel. Can be used in most firefighting applications.
  - Aqueous Film Forming Foam (AFFF)—Most common type of foam. Forms films over Class B fuels to aid in smothering fire. Also dilutes Class B fuels.
  - Compressed Air Foam System (CAFS)—Combines foam mixture and air to make a shaving cream-like substance that is used in similar applications as AFFF.
- ARFF: Aircraft Rescue and Fire Fighting; specialized form of firefighting for airports.
- NFPA: National Fire Protection Association; governing body for fire service operations and training.

References

1. Essentials of Fire Fighting, 6th Edition (2013). IFSTA (International Fire Science Training Association). Fire Protection Publishers.

CHAPTER 14

Water Rescue

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Water rescue is any incident that involves the removal of victims from any body of water other than a swimming pool. Floods are the most common of all natural disasters and generally cause greater mortality than any other natural hazard.

Hazards Associated with Water Rescue

- Human nature: The "need to do something now" can prompt people to make rescue attempts without proper training or equipment.

- Environmental: Hazards can involve extreme temperatures; cold affects ability to think clearly and hampers fine motor skills; heat exhaustion and dehydration are a concern as well.

- Weather: Accelerates hypothermia. In still water body heat is lost 25 times faster than in air at the same temperature.

- Aquatic environment: Be aware of animal life, fish, insects, plant life, seaweed, biohazards, bacterial, and viral risks.

- Dive option hazards: These include barotrauma, decompression sickness, nitrogen narcosis, oxygen toxicity, embolism, fatigue, loss of air, anxiety reactions.

- Ice operation hazards: Cold injuries such as frostbite or hypothermia; thin ice with sudden immersion reflex or entrapment under ice.
- Swift water operation hazards: Strainers and debris, holes, obstructions above or below the water surface.

Safety of a Rescuer – "Throw, Don't Go"

Jumping in the water to rescue a victim is the last resort. Avoid getting into a dangerous situation. Your safety is priority.

Water Rescue PPE

Wet suits/dry suits/exposure suits

Thermal protection

PFDs include a whistle, knife, strobe light, or light stick worn by all personnel in or near water or on a boat

Lifelines, helmet, gloves

Rescue Plan of Action & Methods

First unit on scene sizes up the situation and determines the number and condition of patients. If rescue is deemed necessary, consider the need for additional personnel and equipment.

Secure the immediate area to prevent an increase of victims.

Assess hazards, location, and number of victims. Before commencing extraction, yell clear and simple instructions to the victim. Ensure firm footing and remember the victim is in duress and may pull rescuers into the water.

REACH

Step 1: Reach with an outstretched arm, leg, or other tool (long stick/scarf/clothes) from a crouched or lying position.

- DO NOT enter water any deeper than knee deep, unless tethered.

WADE

Step 2: Test the depth with a long stick before wading in and then use the stick to reach out. Hold on to someone else or the bank.

THROW

Step 3: Throw rope bags, life rings, and floats - anything that will float (this is only effective when the subject is cooperative)

ROW

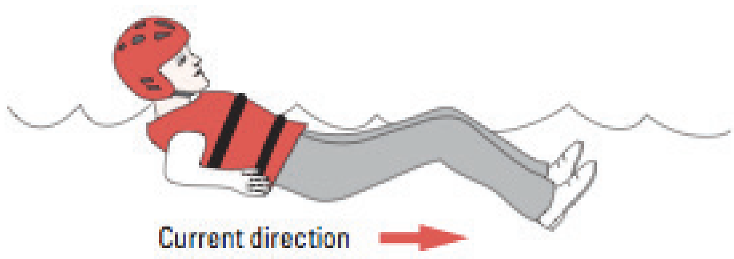
Step 4: Use a boat if you can use it safely. Do not try to pull the person on board in case they panic and capsize the boat.

Continuously monitor situations that could adversely affect the rescue, such as a rise in water, top loads, suspended loads, or shifting of rescue vehicle.

Once the victim has been removed to a safe area, medical personnel should be on scene to evaluate and transport to the hospital if necessary.

Safe Swimming Position

If you get swept away, assume the safe swimming position and navigate with ferry angle. (Image)



Awareness Level Personnel (Resident) may:

- Establish scene controls.
- Establish Incident Command.
- Initiate accountability and safety.
- Evaluate patient condition.
- Activate needed resources.
- Secure and interview witnesses.
- Establish last seen point.
- Identify number of victims, age, and sex of victims.

Sectorization of Rescue Operation

Upstream group: Responsible to watch for and advise of any obstacles and hazards that may hinder the rescue operation.

Downstream group: Prepare to rescue victims and rescuers that may be swept downstream. All members in this group should have a throw rope bag in hand and deploy on both sides to the bank.

River right/left group: Responsible for rigging the opposite end of a rope rescue system.

Rescue group: Responsible for developing an action with command. Once action plan has been developed, rescue group will execute plan in the safest possible manner.

Medical group: Responsible for providing first aid treatment to victims removed from the water.

Rescue Communications

Whistle Commands

1 Blast = Stop and look at me

2 Blasts = Begin the action that we agreed upon or is indicated

3 Blasts (repetitive) = I need help

Hand Signals

One arm in air = I need help

One hand on top of head = I am OK

Rope Signals

1 Tug = OK

2 Tugs = Advance

3 Tugs = Take up slack

4 Tugs = Help

Technique for Mechanical Advantage

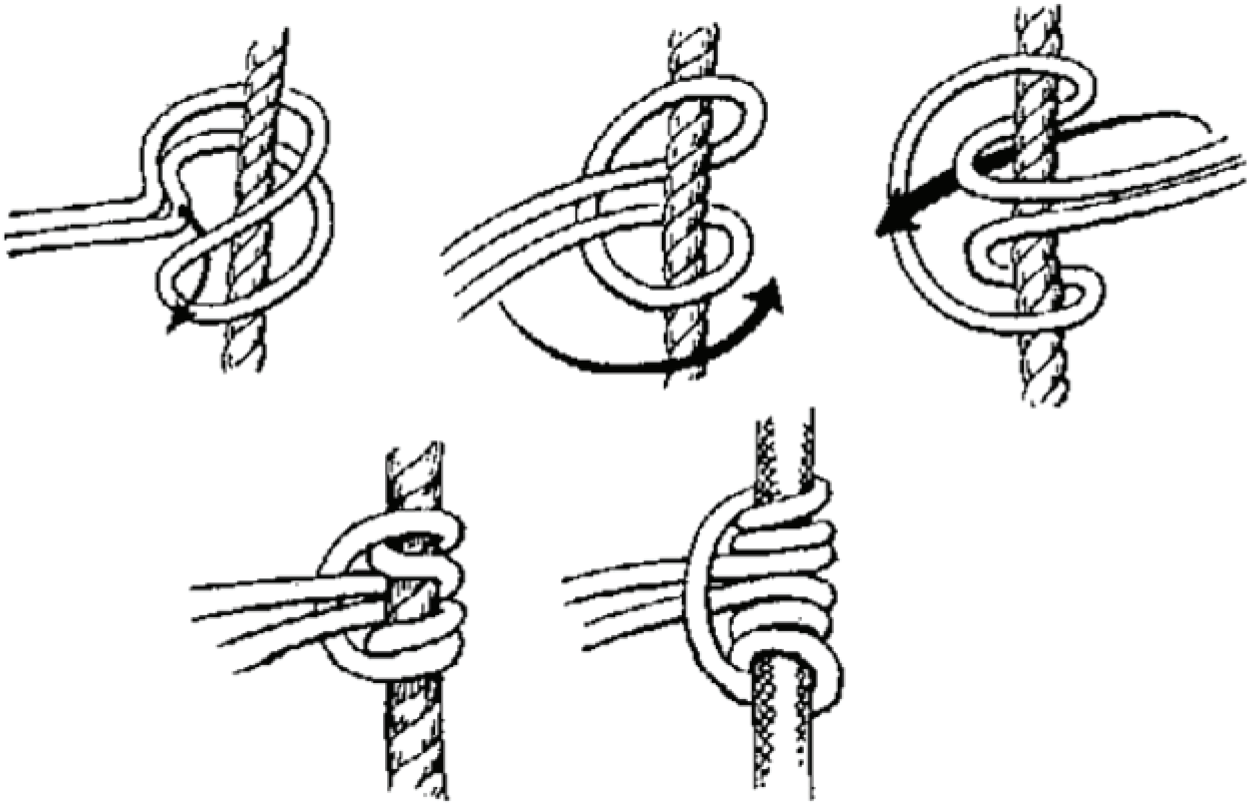
Vector pull: By attaching one end of the rope to an anchor and the other to the pinned object, the rope can then be pulled near the mid-point in a sideways direction to exert a much greater force on the pinned object.

Z drag/pulley system: Theoretical mechanical advantage of 3, giving a 3:1 haul ratio. Requires excess gear, time, and only pulls the pinned object 1 foot for every 3 feet pulled by the user.

Prusik 1 provides the mechanical advantage.

Prusik 2 can be used to hold the position of the rope.

Prusik knot slides easily along a tight rope but jams solidly upon loading.



Drowning

Drowning is a process resulting in primary respiratory impairment from submersion or immersion in a liquid medium. The distinction between salt water and fresh water drowning is no longer important in non-fatal drowning. Both result in hypoxia and pulmonary edema. Panic causes loss of normal breathing pattern and reflex inspiratory efforts, followed by aspiration and reflex laryngospasm, hypoxemia, end organ damage, and death.

Management

Ventilation is priority, unlike in cardiac arrest. If the patient does not respond to 2 rescue breaths that make the chest rise, the rescuer should immediately begin performing high-quality chest compressions. CPR, including the application of an automated external defibrillator, is then performed according to standard guidelines. Cervical spine immobilization is not recommended unless there are clinical signs of injury or concerning mechanism, as it can interfere with essential airway management.

Drowning patients can present with life-threatening arrhythmias. Treat according to ACLS protocols. Assess pulse for at least 1 minute before initiating chest compressions, as pulses may be weak in a hypothermic patient. Heimlich maneuver and postural drainage is no longer recommended.

Hypothermia

Hypothermia is a core temperature less than 35 Celsius. Water does not have to be ice-cold for hypothermia or other cold-related injuries. Most water is well below human core body temperature. Prolonged exposure to water may result in hypothermia. Generally, a hypothermic patient is never considered dead until the core temperature is increased to 32° Celsius.

Mild hypothermia: Core temperature 32-35° C (90-95° F); result is tachypnea, tachycardia, initial hyperventilation, ataxia, dysarthria, impaired judgment, shivering, and cold diuresis.

Moderate hypothermia: Core temperature 28-32° C (82-90° F); proportionate reductions in pulse rate and cardiac output, hypoventilation, central nervous system depression, hyporeflexia, decreased renal blood flow, and loss of shivering. Paradoxical undressing may be observed. Atrial fibrillation, junctional bradycardia, and other arrhythmias can occur.

Severe hypothermia: Core temperature < 28º C (82º F); pulmonary edema, oliguria, areflexia, coma, hypotension, bradycardia, ventricular arrhythmias including ventricular fibrillation, or asystole occur.

References

1. Giesbrecht GG, Hayward JS. Problems and complications with cold-water rescue Giesbert. *Wilderness Environ Med*. 2006;17(1):26-30.
2. Orlowski JP, Szpilman D. Drowning. Rescue, resuscitation, and reanimation. Pediatr Clin North Am. 2001;48(3):627-646.
3. Poole J, Hogan DE. Disaster Medicine – Floods. Wolters Kluwer Health. 2007
4. Water Rescue Awareness – Pasco Fire Department
5. Pendley T. The Essential Technical Rescue Field Operations Guide. 4th ed. 2003 Pendley.

TABLE

Clinical staging scheme described by International Commission for Mountain Emergency Medicine (“The Swiss System”)

ICAR-MEDCOM hypothermia (HT) scale
International Commission for Mountain Emergency Medicine hypothermia scale

Hypothermia (HT) stage	Clinical assessment	Expected core temperature, C° (F°)*
HT I	Clear consciousness with shivering	35-32 (95-89.6)
HT II	Impaired consciousness without shivering	32-28 (89.6-82.4)
HT III	Unconsciousness (circulation present)	28-24 (82.4-75.2)
HT IV	Apparent death (circulation absent)	<24-13.7 (<75.2-56.7)*
HT V	Death due to irreversible hypothermia	<13.7-9 (56.7-48.2)*

The Swiss System is intended to help prehospital rescuers estimate the severity of hypothermia by observing certain clinical signs. Resuscitative efforts should be continued until the temperature reaches 32-35° C (90 to 95° F).

Passive external rewarming (PER) is the treatment of choice for mild hypothermia. Remove wet clothes and apply blankets or different types of insulation.

Active external rewarming (AER) is used for moderate to severe hypothermia or failure to respond to passive rewarming. Use a combination of warm blankets, heating pads, radiant heat, warm baths, or forced warm air applied directly to the patient's skin. Rewarming of the trunk should be undertaken before the extremities to minimize hypotension and acidemia due to arterial vasodilation and core temperature afterdrop. After resuscitation, pay careful attention to potential complications, including hypotension during active rewarming, arrhythmia, hyperkalemia, hypoglycemia, rhabdomyolysis, bladder atony, and bleeding diathesis.

CLINICAL SCENARIOS

- Sick & Undifferentiated
- Cardiac Arrest
- Shock & Hypotension
- MVC
- Penetrating Trauma
- EMS Airway
- Termination of Resuscitation

CHAPTER 15

The Sick and Undifferentiated Medical Patient

Matt Friedman, MD
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At 17:00, two paramedics respond to the home of a 65-year-old man for a 'sick' call type. No other dispatch information is available for the crew pre-arrival. On scene, the patient states he feels "unwell" but is unable to better characterize his symptoms other than mild nausea. He has a PMH of chronic back pain and no other medical problems, with infrequent primary care visits. He denies any specific complaints other than his typical back pain. His wife reports that he was acting normal earlier today and she doesn't know what's wrong with him. She's a bit surprised he asked her to call 911, saying "He wasn't really complaining all that much." He takes naproxen for his back pain, which generally alleviates the pain. He denies any allergies or prior surgical history.

EMS providers rely on the initial dispatch information to guide their assessment and treatment on scene such that faulty dispatch information may steer EMS providers down the wrong path, wasting valuable time and leading to ineffective or inappropriate prehospital care. Thus the role of CRO is critical as the initial part of the EMS chain to provide the prehospital standard of care.

Emergency Medical Dispatch (EMD)

A medical call-receiving operator (CRO) trained in EMD has limited time to accurately identify the chief complaint and obtain vital medical information from the 911 caller. They are trained to collect information in a structured manner to perform priority dispatch. Due to callers' heightened anxiety or altered mental status, unreliable or misleading information is often transmitted to the responding EMS crews.

Undertriaged dispatch: Inappropriate or unprepared resources rendering substandard level of care (eg, BLS providers responding to a "sick" call type that turns out to be a patient in severe respiratory distress.

Overtriaged dispatch: Excessive resources responding with lights and sirens, which puts the public and responders at risk and at great cost to the 911 system, to a stable patient (eg, first responders, BLS ambulance, ALS ambulance, EMS supervisor responding to a "Cardiac Arrest" call that turns out to be a person sleeping).

Clinical Decisions

EMS providers must accumulate a great deal of information in a short time period. They then incorporate this information with their clinical skills and exam into their clinical decision-making. Delays in treatment and transport can impact patients' morbidity and mortality. Providers must make quick decisions based on limited information while providing thorough and efficient care. This has been termed heuristics. There are 4 main strategies that providers use in clinical decision-making (Table 1).

History and Physical

Field personnel must acquire a detailed and unbiased history using effective communication strategies. Regardless of the dispatch information, providers should approach each patient in the same manner. A balance of open-ended (Can you describe your pain?) and close-ended (Is your pain sharp or dull?) questions will

TABLE 1:

Clinical Decision-Making Strategies
1. Pattern recognition (eg, making a diagnosis upon seeing the patient; frequently automatic, subconscious, and based on years of experience)
2. Guideline-based (eg, Advanced Cardiac Life Support algorithms)
3. Knowledge-based (a provider generates a presumptive diagnosis and uses available data to adjust that diagnosis)
4. Event-driven process (ie, treating the patient first and then making a diagnosis)

produce a sufficient, succinct history. Traditional teaching professes that a diagnosis can usually be made by a thorough history alone.

When assessing a patient with an undifferentiated dispatch code, EMS providers identify a prehospital chief complaint and treat the patient in accordance with the regionalized protocols. Occasionally, however, providers are unable to identify a specific prehospital chief complaint leading to the "undifferentiated" prehospital patient. If the patient is undifferentiated after obtaining a detailed history, providers follow the strategies listed in Table 2.

TABLE 2.

The History
Obtain information to confirm or exclude life-threatening conditions.
Ensure there are no high-priority symptoms affecting the patient's ability to give an accurate history (eg, hypoglycemia, acute CVA).
Ensure patient is alert and oriented x3 with no underlying cognitive impairment due to drug ingestion, intoxication, delirium, or baseline dementia.
Use adjuncts to facilitate the history (eg, visual aids or drawing diagrams).
Optimize communications by avoiding medical jargon and asking simple questions.
Obtain useful information and baseline mental status from family members or bystanders if possible.
Generate a "most likely" and "most life-threatening" list of differential diagnoses.
Avoid decision-making when overly stressed or angry.

If patients remain undifferentiated despite a thorough history, providers should perform a thorough physical exam (PE) to augment the history that has been elicited. Obtaining a complete set of vital signs is the first step of a physical exam. Afterwards, utilize the strategies listed in Table 3.

Diagnostic Assessment

If the history and physical exam have not collectively identified a chief complaint, providers should use appropriate prehospital diagnostic tests to facilitate a working diagnosis, such as a point of care blood glucose level or 12-lead ECG. Some EMS systems offer prehospital point of care lactate testing to assist the providers in their differential diagnosis (eg, early diagnosis of sepsis). When crews have identified an undifferentiated patient, they should minimize the time to transport while continuing to obtain information and reassessing vital signs as warranted.

TABLE 3.

The Physical Exam
Ensure a complete and uninterrupted PE.
Clarify the history while conducting the PE.
Perform an environmental scan of the patient's physical surroundings to complement the history.
Have a structured and simple differential diagnosis or impression.

Knowing the importance of a good transition of care to the triage nurse, especially with an undifferentiated patient, the crew clearly explains they do not have a presumptive diagnosis. Importantly, they note, he just had one episode of emesis prior to arrival and an acute worsening of his chronic back pain. The senior paramedic states, "I'm not sure what's going on with him, and that makes me even more concerned about him." The triage nurse listens to their assessment and obtains a new set of vital signs: 105/70, 110, 20, 97%. The EMS providers astutely notice the drop in blood pressure since their previous measurement, which prompts the nurse to triage the patient into the critical care area of the ED. After evaluation by the ED staff, and with the benefit of a bedside ultrasound, a ruptured abdominal aortic aneurysm is quickly diagnosed. As the crew walks out of the ER, they realize the quality care they provided led to a quick diagnosis of a critical condition and any delay in assessment, treatment, or transport would have resulted in missing this critical life-threatening event.

CHAPTER 16

Cardiac Arrest

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At 13:00, two paramedics responded to a call for a cardiac arrest at a local restaurant. Per the 911 dispatcher, a 66-year-old man was eating at the restaurant with his wife when he collapsed. A bystander attempted to palpate a pulse and was unsuccessful. CPR (compressions only) was started. An AED (automated external defibrillator) had been applied to the patient's chest. A shock was advised, and the bystanders continued CPR following the shock.

Cardiac Arrest

There are an estimated 435,000 out-of-hospital cardiac arrests each year, according to the American Heart Association's Heart Disease and Stroke update 2014. Thus it is important to review adult and pediatric advanced cardiac life support algorithms, which have changed as of the American Heart Association's 2015 update. The most recent guidelines are not a significant change from those released in 2010 in relation to basic life support (BLS) and the use of automated external defibrillators (AED); however, key changes are important to note, including employment of a "pit crew" approach, quality of chest compressions, use of mechanical compression devices, changes to medications utilized, and implementation of therapeutic hypothermia in return of spontaneous circulation (ROSC).

The employment of the pit crew, or assignment of roles to each team member, optimizes utilization of resources. For instance, the 2 most important determinants of outcome following cardiac arrest are early defibrillation and quality of CPR.[1] Bystander-initiated CPR, as well as a shock delivered in <5 minutes, have been shown to significantly improve a patient's survival following cardiac arrest.[1,2] Yet, historical information can play a huge role in patient outcomes:[1]

- Did anyone witness the arrest?
- What time was the person last seen "normal"?
- What time did the arrest occur, and what was the person doing at that time?
- Was there any intervention prior to arrival (CPR initiated, AED applied, shock delivered)?
- Is there any pertinent past medical history (PMH)?
- What medications does the patient take?
- Any possibility for ingestion or overdose?

- Determine code status.

A cardiac arrest in the field should be organized similar to a cardiac arrest in the hospital (number of personnel may vary by system):

1. A recorder to keep track of the time and interventions
2. 2 people performing CPR
3. 1 person to draw up medications

The paramedics arrived on scene approximately 5 minutes after arrest. An engine crew from the local fire department arrived simultaneously. Two firefighters take over CPR from the bystanders and continue with high-quality chest compressions and begin bag-valve mask ventilation. One paramedic starts recording, noting times of interventions and changes in the patient's status. The second paramedic assesses the AED, finding it to be connected to the patient correctly. He then applies a cardiac monitor. He speaks with the patient's wife and bystanders, gathering pertinent past medical history and events prior to the cardiac arrest. Prior to lunch the patient had been complaining of chest discomfort. While eating he fell over and was found by a bystander to have no palpable pulse. CPR was started, and the AED was applied. One shock was given. The patient's past medical history is significant for hypertension and hyperlipidemia. He takes Lisinopril and Lipitor and has a 20-pack year tobacco history.

CPR Quality

It is important to monitor CPR quality.[3] In the best scenarios, CPR will:

- Push hard and fast: compress at least 5 cm (2 inches) and between 100-120 compression/minute
- Allow for full relaxation between compressions (avoid leaning on the patient)
- Minimize interruptions in compressions, including when rotating and between defibrillation
- It is also important to avoid hyperventilation as this can lead to reduced cardiac output1
- No advanced airway: 30:2 (adult) or 15:2 (pediatric) compression-to-ventilation ratio
- Advanced airway: continuous compressions and 1 breath every 6 seconds (10 breaths/minute)
- If advanced airway is placed remember to confirm placement:
- Visualizing endotracheal tube passing between vocal cords
- Confirm bilateral breath sounds
- End-tidal CO2
- Waveform capnography

Be cognizant of the reversible causes.[4] Some conditions to keep in mind include:

- Hypovolemia
- Hypoxia
- Hydrogen Ion (acidosis)
- Hypo/Hyperkalemia
- Hypothermia
- Tension pneumothorax
- Tamponade (cardiac)
- Toxins
- Thrombosis (pulmonary)
- Thrombosis (coronary)

If return of spontaneous circulation (ROSC) is achieved:

1. Check pulses and blood pressure
2. PETCO2 typically will show an abrupt and sustained increased (usually >40 mmHg)1
3. Proceed to the ROSC pathway **AHA post arrest guidelines**[5]
4. Obtain 12 lead EKG ↦ Prioritize transport to a STEMI/ Hypothermia center

The firefighters continued CPR. IV access was obtained and an advanced airway was placed. At 2 minutes, pulse and rhythm checks were done. The patient was still pulseless, and ventricular fibrillation was seen on the monitor. A shock was given, followed by epinephrine 1mg. Capnography showed an ETCO2 of 22. The firefighters continued with high-quality CPR, and 2 minutes later another pulse and rhythm check was completed. The patient was found to have a pulse, and NSR was seen on the monitor. Capnography showed an ETCO2 of 55. The ASA post-arrest guidelines were intiated12 and the patient was prepared for transport to the nearest STEMI center. An EKG obtained post-arrest showed ST-segment elevation in the anterior leads. This was relayed to the accepting STEMI center and the cardiac catheterization suite was readied.

References

1. Ward KR, Neumar RW. Adult Resuscitation. In: Marx JA, Hockberger RS, Walls RM, eds. Rosen's Emergency Medicine: Concepts and Clinical Practice, 7th edition. Philadelphia: Mosby, 2009:53-63.
2. Ornato JP. Sudden Cardiac Death. In: Tintinalli JE, et al, eds. Tintinalli's Emergency Medicine: A Comprehensive Study Guide, 7th edition. New York, NY: McGraw, 2009:63-67.
3. Friedlander AD, Hirshon JM. Basic Cardiopulmonary Resuscitation in Adults. Tintinalli JE, et al, eds. Tintinalli's Emergency Medicine: A Comprehensive Study Guide, 7th edition. New York, NY: McGraw, 2009:67-73.
4. American Heart Association. Doses/Details for the Cardiac Arrest Algorithms. ACLS: Cardiac Arrest, Arrhythmias, and Their Treatment.
5. American Heart Association. Immediate Post-Cardiac Arrest Care Algorithm. ACLS: Cardiac Arrest, Arrhythmias, and Their Treatment.

CHAPTER 17

Shock & Hypotension

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The detection and management of shock in the prehospital environment has been historically limited. While technical advances and new research have led to significant changes in recent years regarding the prehospital phase of care of these critically ill patients, there remain significant limitations on the ability to manage shock in the field. This creates a difficult balance between stabilization in the field and rapid transport to the hospital for definitive care.

What is shock?

Shock is the widespread failure of the circulatory system to supply adequate oxygen and nourishment to the tissues and organs of the body.

What is perfusion?

Perfusion is the supply of oxygen to cells and tissue with subsequent removal of wastes as a result of blood flow through the capillaries.

What is hypoperfusion?

Hypoperfusion is the inability to supply oxygen and remove wastes from the cells and tissues due to poor circulation of blood.

What is SIRS?

Systemic Inflammatory Response Syndrome (SIRS) may be due to infection, but other causes, such as burns and pancreatitis, may exist. It requires 2 of the following:

- Temperature < 36oC or > 38oC
- Pulse > 90 beats per minute
- Respiratory rate > 20 breaths per minute or $PaCO_2$ < 32 mmHg
- WBC > 12000 or < 4000 or differential with > 10% bands

Stages of shock

Compensated or Non-progressive

Low perfusion activates multiple systems to maintain and restore perfusion, resulting in:

- Tachycardia
- Vasoconstriction
- Renal system retaining fluid and volume

- Maximization of blood flow to the brain, lungs, and heart
- Few symptoms
- Aggressive management slows progression

Decompensated or Progressive

Failure to compensate; unable to improve and maintain perfusion.

- Symptoms reflect poor perfusion.
- Oxygen deprivation to the brain causes confusion.

Irreversible

Prolonged lack of perfusion results in permanent damage to organs and tissues, resulting in:

- Cardiac failure
- Renal failure
- Cell death

Endpoint is death of the patient.

What are the different types of shock?

- Hypovolemic
- Distributive
- Cardiogenic

- Obstructive
- Neurogenic

HYPOVOLEMIC SHOCK

Hypovolemic shock is the rapid reduction of blood volume, typically due to hemorrhage, that results in activation of baroreceptors. This has a positive inotropic and positive chronotropic effect. As hypovolemia progresses, catecholamines and hormones are released, resulting in vasoconstriction and tachycardia. Hemorrhage first increases pulse and cardiac contraction and then increases vasoconstriction to maintain tissue perfusion. This narrows pulse pressure.

As blood loss continues, ventricular filling decreases, cardiac output falls, and there is a reduction in systolic BP. As CO2 decreases, blood flow to noncritical organs and tissues decreases, leading to the production of lactic acid. After 1/3 of total blood volume is lost, cardiovascular reflexes no longer sustain adequate filling of the arterial circuit and frank hypotension occurs. Urine output decreases and thirst is stimulated to maintain circulating volume.

How is hypovolemic shock managed?

Resuscitation strategies are to optimize tissue perfusion while avoiding complications of overaggressive volume replacement. The goal of a trauma assessment is early recognition of circulatory dysfunction prior to development of hypotension and end-organ damage.

If there is a bleeding wound, apply direct pressure. If the wound is on an extremity and bleeding does not cease, elevate the extremity above the level of the heart. Apply additional dressings as needed. If bleeding continues on the arm, apply direct pressure to the brachial artery. If the wound is on a leg, apply direct pressure to the femoral artery. Application of cold packs will cause vasoconstriction.

Additional management techniques include:

- If there as a penetrating injury, stabilize the object if it is still impaled.
- Maintain airway.
- Apply high flow oxygen and be prepared to intubate at any point.
- Do not give an anticoagulant, such as aspirin.
- If there is no concern for a spinal cord injury, place the patient in Trendelenburg position.
- Keep the patient warm.
- Administer bolus of normal saline.

What is permissive hypotension?

A combination of the patient's natural coagulation cascade, hypotension, and vessel spasm will temporarily arrest traumatic hemorrhage. Often the patient will have no apparent bleeding, but once resuscitation occurs and hypotension reverses, rapid arterial bleeding occurs. Permissive hypotension is the minimization of fluid resuscitation in the prehospital setting in patients with palpable radial pulses and normal mental status. Goal SBP is around 90. Aggressive fluid resuscitation could maintain sufficient blood flow to prolong survival until definitive hemorrhage control occurs. Contraindications to permissive hypotension include traumatic brain injury, spinal cord injury, patients who are hypertensive, patients with angina pectoris and cardiovascular disease, carotid artery stenosis, impaired renal function, and intermittent claudication stage III/IV.

DISTRIBUTIVE SHOCK

Distributive shock is peripheral vasodilation and blood flow maldistribution, commonly caused by sepsis or anaphylaxis.

Septic shock is caused by infection with any microbe, although frequently no specific organism is identified. Three major issues must be addressed during resuscitation: hypovolemia, cardiovascular depress, and induction of system inflammation.

Patients have relative hypovolemia as a result of increased venous capacitance, which reduces right ventricular filling. GI loss, tachypnea, sweating, decreased oral intake, and third spacing also contribute to relative hypovolemia.

Cardiovascular depression and induction of systemic inflammation are the other two issues addressed during resuscitation. Severe sepsis is SIRS with suspected or confirmed infection and associated organ dysfunction or hypotension. Septic shock is SIRS with suspected or confirmed infection with hypotension despite adequate fluid resuscitation. In the presence of an infection, inadequate tissue perfusion defines septic shock. Hypoxemia is more severe in septic shock.

Anaphylaxis is an antigen mediated immune reaction to a presensitized antigen. This causes increased bronchial muscle tone, increased mucous membrane secretion, decreased vascular tone, capillary leakage, and urticaria. Hypotensive patients should remain supine due to complications from massive fluid shifts during volume depletion. Airway obstruction and cardiovascular collapse are the most common causes of death.

How is septic shock managed?

Airway management is always priority in resuscitation of any patient. Two large bore IVs with aggressive normal saline infusion and vasoactive agents in patients refractory to fluid resuscitation should be initiated. Norepinephrine, while not commonly used by ground EMS, is the preferred agent as the patient is typically tachycardic. Blood sugars should be monitored as patients are commonly profoundly hyperglycemic. For those prehospital agencies with established protocols, early antibiotic administration should occur, with the preferred agents being vancomycin and piperacillin/tazobactam due to the broad spectrum nature. (Note: Antibiotics are not common on ground ambulances.)

How is anaphylactic shock managed?

Immediate administration of epinephrine (1:1000) 0.3 mg IM in the lateral thigh should be performed. This may be repeated in severe reactions. Diphenhydramine 50 mg IV/IM, methylprednisolone 125 mg IV, and fluid resuscitation are the mainstays of treatment. Consider albuterol 2.5 mg/3 mL nebulizer if bronchospasm persists following epinephrine. If refractory hypotension persists, dopamine 5 to 20 mcg/kg/min should be initiated if available.

CARDIOGENIC SHOCK

Cardiogenic shock results when more than 40% of the myocardium undergoes necrosis from ischemia, inflammation, toxins, or immune destruction. Similar to hemorrhagic shock, alterations in circulation and metabolism occur. There is interference with blood flow from the heart, resulting in dyspnea, tachycardia, pulmonary or peripheral edema, and cyanosis.

How is cardiogenic shock managed?

The goal of management is adequate oxygenation of the myocardium. Oxygen and continuous positive airway pressure

(CPAP) therapy are used to relieve dyspnea. Furosemide may be administered if pulmonary edema is noted upon exam. However, note the furosemide may be detrimental in patients who are dehydrated secondary to infection. Preferred vasopressors for refractory hypotension include dopamine, dobutamine, and norephinephrine if available.

OBSTRUCTIVE SHOCK

Obstructive shock is an extracardiac obstruction to blood flow. This is commonly caused by a pneumothorax, pulmonary embolism, or pericardial tamponade.

How is obstructive shock managed?

The most important management is to maintain adequate oxygenation.

- Tension pneumothorax $\mapsto$ Needle decompression on affected side in second intercostal space along mid-clavicular line.
- Pulmonary embolism $\mapsto$ High flow oxygen and intubation.
- Pericardial tamponade $\mapsto$ Pericardiocentesis.

NEUROGENIC SHOCK

Neurogenic shock affects autonomic responses. Sympathetic outflow is disrupted, causing unopposed vagal tone. This results in hypotension and bradycardia with warm, dry skin. This is the ONLY type of shock where the skin remains warm and dry. The higher the injury, the more likely severe symptoms will occur. Neurogenic shock, though, is a diagnosis of exclusion.

How is neurogenic shock managed?

Airway management is of utmost importance. For hypotension, fluid resuscitation with normal saline and vasopressors for refractory hypotension should be administered. If symptomatic bradycardia occurs, administer atropine 0.5 mg IV. If atropine does not reverse bradycardia, a transcutaneous pacemaker should be placed. EMS should transfer the patient to a facility with neurological and neurosurgical services.

What is spinal shock?

Spinal shock stems from acute spinal cord injury and results in the loss of all voluntary neurologic activity and reflexes below the level of the injury. Flaccid paralysis and loss of sensation occur. Spinal shock can last months. Some sources group spinal shock and neurogenic shock together. Although spinal and neurogenic shock can occur in the same patient, they are not the same disorder. The management, though, is the same.

References

Marx J, Hockberger R, Walls R, Adams J, Rosen P. Rosen's Emergency Medicine: Concepts & Clinical Practice. 7th ed. Maryland Heights, MO: Mosby; 2010.

CHAPTER 18

MVC: Blunt Trauma

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At 08:15, paramedics are called to the scene of a construction site on a major highway, where a 36-year-old male has been crushed against the median by a semi-truck. Access to the site is complicated by blockage of 2 of the highway's 3 lanes during morning rush hour traffic. Police have secured the scene, and traffic is stopped. The semi-truck has been moved away from the scene. On arrival, the patient is lying face-up on the asphalt, minimally responsive and surrounded by his concerned, shouting co-workers. His breathing is severely labored, and there is blood coming from his mouth. He is moaning, his face and neck are purple, and he has obvious fractures of both legs. The foreman knows little about the patient's health other than he's a smoker and rarely misses work. No one has been able to contact the patient's wife, but efforts are continuing.

Scene Safety

Local law enforcement, fire, and EMS will be first to the scene of a motor vehicle collision (MVC). Before addressing the victims of the crash, it is essential the scene be assessed for safety. You must also anticipate any potential risks, including:

- Weather
- Flooding Fire/gasoline
- Chemical Spills
- Power lines
- Traffic
- Onlookers

Traffic should be rerouted and the scene blocked off before assessment can begin. EMS should wear appropriate protective and reflective gear that allows for full body movement. Once the scene is secure, triage and stabilization for transport can begin. Fire will begin extricating victims trapped in vehicles. Be mindful of maintaining C-spine precautions when appropriate.

Remain Alert to Your Surroundings at all Times

Initial Assessment

In an MVC, the speed of the vehicles involved, ejection of passengers, the use of restraints, and need for extrication all can affect severity of injury.[1] Recall Newton's Laws of Motion. Rapid deceleration, crushing, and ejection all produce significant forces on the body both internally and externally.[2,3] Therefore, not all injuries are obvious.

Assessment of the patient should proceed with mechanism of injury in mind. (Table 1.)

TABLE 1.

Initial Assessment

Mechanism	Considerations	Possible Injuries
Head-on collision		Facial injuries Lower extremity injuries Aortic injuries
Central cord syndrome Rear-end collision		Hyperextension injuries of cervical spine Cervical spine fracture
Lateral (T-bone) collision		Thoracic injuries Abdominal injuries: spleen, liver Pelvic injuries Clavicle, humerus, rib fractures
Rollover	Greater chance of ejection Significant mechanism of injury	Crush injuries Compression fractures of spine
Ejection	Likely unrestrained Significant mortality	Spinal injuries
Windshield damage	Likely unrestrained	Closed head injuries, coup and countercoup injuries Facial fractures Skull fractures Cervical spine fractures

Steering wheel damage	Likely unrestrained	Thoracic injuries Sternal and rib fractures, flail chest Cardiac contusion Aortic injuries Hemo/ pneumothoraces
Dashboard damage		Pelvic and hip fractures/dislocations
Restraint use	Reduced morbidity with 3-point restraints	Sternal rib fracture Chance fracture, abdominal injuries Cervical spine fracture
Airbag deployment	Front-end collisions Less severe head/ upper torso injuries Not effective for lateral impacts More severe injuries in children (improper front seat placement)	Upper extremity soft tissue injuries/ fractures Lower extremity injuries/fractures

Source: Marx J, Hockberger R, Walls R, Adams J, Rosen P. Rosen's Emergency Medicine: Concepts & Clinical Practice. 7th ed. Maryland Heights, MO: Mosby; 2010.

REMEMBER YOUR ABCs

Initial assessment of the patient at the scene is ABC:

A – AIRWAY: Ask a simple question, such as "Can you tell me your name?" If they do not respond, are there signs of obstruction or noisy breathing? Jaw-thrust to open the airway. Try repositioning if needed. If the jaw-thrust doesn't work, use the head tilt–chin lift method.[4] Use suction as needed. If the airway is clear, can the patient maintain it on his or her own? If not, insert an airway adjunct. Take care with patients with facial fractures, as the airway may be harder to manage. Maintain spinal precautions where possible. Avoid over-extension of the neck during ventilation and intubation[4] and place a C-Collar where indicated.

B – BREATHING: If the patient is responsive but not breathing adequately, give high-flow oxygen and be prepared to help ventilate if needed. If the patient is unresponsive and breathing adequately, place the appropriate adjunct or assess for intubation. Give high-flow oxygen. If the patient is unresponsive and not breathing adequately, place an adjunct and provide ventilation with a bag-valve-mask (BVM) device using high-flow oxygen. Any signs of inadequate breathing should prompt an immediate examination of the chest.[4] Flail chest (independently moving segment of chest wall) or lack of breath sounds that suggest pneumothorax require immediate intervention.[5]

C – CIRCULATION: A patient who is responsive and/or breathing adequately will likely have an intact pulse. Check the radial for at least 5 seconds. If you cannot feel a pulse, check the carotid site. If any doubt exists, begin compressions and prioritize transport. If a pulse is present, how is your patient's overall perfusion? Look for major bleeding and control it. Assess the patient's skin, noting color and condition. If the patient is a child, use the brachial site to check a pulse. Check capillary refill. It should be less than 2 seconds in adults and children.[6] Pregnant patients (advanced trimester) may need to be tilted to the left on the backboard to facilitate venous return.[7]

Certain mechanisms of injury indicate a **priority patient,** no matter how minor the injuries seem to be. Regardless of injury, any patient who has been fully or partially ejected from a vehicle, was in the same vehicle as someone who died, or was in the path of significant intrusion should be considered a priority patient. Pedestrian, bicyclists, and motorcyclists with an impact speed over 20 mph also fall into this category. Also consider age; the very young and very old are unable to compensate and may deteriorate quickly with seemingly minor injuries.[7] Older adults may have decreased pain perception that can mask the severity of an injury.[8] With priority patients, a detailed exam can be done en route. If the patient is not a priority, you can proceed with a focused history and physical exam at the scene.

Injuries that Indicate a Priority Patient:

· Poor general impression

• Unresponsive or altered mental status
• Airway compromise
• Inadequate or difficult breathing
• Inadequate perfusion or shock, including cardiac arrest
• Severe bleeding that can't be controlled

Transport

Once en route, EMS notifies the receiving transfer center/ED of basic details:

- Patient age and sex
- Mechanism of injury
- Vital signs
- Apparent injuries
- IV access
- Interventions performed: intubation, needle thoracostomy

Early notification enables emergency department staff to prepare for the patient's needs:

- Notifying additional teams (eg, trauma surgery, orthopedics, neurosurgery, obstetrics)
- Anticipate procedures (eg, intubation, chest tube, thoracotomy)

- Blood transfusion (eg, Central line, rapid volume infuser, O negative PRBC)

REASSESS THE PATIENT FREQUENTLY; PATIENT STATUS CHANGES QUICKLY.

While in transit, a paramedic notices the patient has stopped moving, and pulse oximetry is now declining. The blood pressure cuff is currently cycling. While there is a tracing on the monitor, a carotid pulse check reveals PEA arrest. The paramedic alerts the team, and CPR is initiated at 8:47 as EMS arrives at the ED. CPR continues as the patient is wheeled into the trauma bay.

Once at the ED, information should be communicated to the receiving staff or trauma team leader in a clear and succinct manner. In addition to any history obtained, the following should be included if applicable:

- Seat belt use
- Steering wheel deformation
- Airbag deployment
- Direction and speed of impact
- Damage to the vehicle (especially intrusion)
- Distance ejected
- Height of fall

- Body part landed upon
- Death of other passengers

Assessment begins anew by the receiving team even during the handoff. Reassessment is essential in blunt trauma, as the variety of injuries can manifest in countless ways. Stability of the patient is dependent upon the vigilance of the treatment team. Clear communication and the maintenance of a calm environment facilitate successful treatment in critical trauma situations.

Upon arrival, report was quickly given, and resuscitation continued. Adequate access had already been established. The patient was intubated and had a chest tube placed for pneumothorax during the initial assessment with spontaneous return of circulation. Such an outcome wouldn't have been possible without the critical assessment skills and the efficient action of all personnel.

References

1. Lerner EB, Shah MN, Cushman JT, et al. Does mechanism of injury predict trauma center need? *Prehosp Emerg Care.* 2011;15:518.
2. Wanek S, Mayberry JC. Blunt thoracic trauma: flail chest, pulmonary contusion, and blast injury. *Crit Care Clin.* 2004;20:71.
3. McGwin G Jr, Reiff DA, Moran SG, Rue LW 3rd. Incidence and characteristics of motor vehicle collision-related blunt thoracic aortic injury according to age. *J Trauma.* 2002;52:859
4. Hobgood C, Croskeery P, Wears RL, Hevia A. Patient safety in emergency Medicine. In: Tintinalli J, Kelen GD, Stapczynski JS, eds. *Emergency Medicine: a comprehensive study guide*, 6th ed. New York, NY: McGraw-Hill;2004: 1912-1918.
5. Wanek S, Mayberry JC. Blunt thoracic trauma: flail chest, pulmonary contusion,

and blast injury. *Crit Care Clin*. 2004;20:71.

6. Chapman DM, Char DM, Aubin CD. Clinical decision making. In: Marx JA, Hockberger RS, Walls RM. Rosen's emergency medicine: concepts and clinical practice. 5th ed. Maryland Heights, MO: Mosby; 2002: 107-115.
7. Gross E, Martel M. Multiple trauma. In: Marx JA, Hockberger RS, et al., eds. *Rosen's Emergency Medicine: Concepts and Clinical Practice.* 7th ed.Philadelphia, PA: Mosby Elsevier; 2010.
8. Chapman DM, Char DM, Aubin CD. Clinical decision making. In: Marx JA, Hockberger RS, Walls RM. Rosen's emergency medicine: concepts and clinical practice. 5th ed. Maryland Heights, MO: Mosby; 2002:107-115.

CHAPTER 19

Penetrating Trauma

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The major paradigm within EMS for penetrating trauma is the rapid transport of patients to definitive surgical care – a "load and go" strategy. Prehospital interventions that may delay transport should be reserved only for truly immediate life-threatening injuries identified on the primary survey. Note the survey should assess for cavitation, or the rapid expansion and contraction of tissues from the shock wave of the penetrating object.

Epidemiology and General Principles

Penetrating trauma in the United States:

- ~ 20% of trauma
- 40-50% of all trauma mortality
- More likely to cause mortality in the first 72 hours vs. blunt trauma (Table)

Out-of-Hospital Management

PRIMARY SURVEY

Penetrating trauma patients are assessed using "CABC," or Catastrophic Hemorrhage, Airway, Breathing, Circulation.

C - CATASTROPHIC HEMORRHAGE

Massive external hemorrhage is the first priority in management, with direct pressure being the mainstay of treatment. Prior to riding along, be familiar with the different bandages and supplies carried on board for hemostasis.

Tourniquets

Tip: After tourniquet application, it is normal to see some oozing but not frank arterial spray.

Rapid exsanguination from penetrating isolated extremity trauma accounts for up to 10% of exsanguination deaths.

TABLE

Penetrating Trauma

VELOCITY	WEAPON TYPE	FEET PER SECOND	CAVITATION
Low	Knives, arrows	< 1000 fps	No
Medium	Handgun, shotgun	> 1000 fps	Yes
High	Assault weapons, rifles	Up to 2500 fps	Yes
Very high	Debri from explosions	Up to 4500 fps	Yes

- Three-quarters of such wounds will be in the lower extremities.
- The majority are proximal to the knee or elbow.

Tourniquets improve mortality. Properly used tourniquets:

- Do not increase permanent neurovascular injury.
- Do not change ultimate extent of amputation required.

Application Principles:

- Place 2 or more inches proximal to the point of injury.
- Device should be wide:
  - Lower extremity bleeding is difficult to control with tourniquets less than 1 inch wide.
  - Increased width may also reduce local tissue damage and complication.
- Device should be tightened until bleeding stops.
- Clearly document application time on device.
- Failure to control bleeding, or loss of previously controlled bleeding, should prompt placement of a second tourniquet more proximal to the first.
  - Note: The first device should not be loosened or removed.

- Ultimately, rapid transport to obtain an alternative, definitive manner of controlling hemorrhage remains the goal; ideally limit tourniquet time to less than 2hrs.

Topical Hemostatic Agents

Uncontrolled hemorrhage accounts for up to 80% of early civilian trauma deaths; a small percentage of these are from isolated extremity injury. Most of the civilian trauma hemorrhage is due to liver and cardiac injuries, with almost one-third involving a major vessel injury.

Topical hemostatic agents are an option for wounds not amenable to tourniquets. These products can be used to rapidly pack penetrating wounds with pulsatile bleeding; in such cases, the source of the bleeding should be visible or accessible with a finger (eg, very proximal femoral artery injuries over the groin, abdominal injuries, etc.).

Tranexamic Acid

- Tranexamic acid (TXA) may be of benefit for patients at risk for significant internal bleeding, especially if time to definitive care is delayed. TXA is a lysine derivate that prevents plasmin and plasminogen activity, thus reducing clot dissolution. Two major studies show roughly 10% mortality reduction (penetrating and blunt trauma combined).

TXA is often given as bolus, followed by infusion:

- 1g over 10 min, then 1g over 8 hrs; best results if given within 3hrs of injury. It is always important to consider the mechanism, patient's vital signs, and overall clinical scenario prior to administration.
- Complications potentially include coagulant phenomenon such as MI, PE/DVT; however early studies have not shown increase in mortality from use.

TXA's role in civilian EMS remains unclear; it is just starting to be integrated into many EMS systems.

CHAPTER 20

The EMS Airway

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The EMS airway follows the same basic principles as in the hospital; however, it comes with its own unique challenges and limitations. In the emergency department there is greater staffing, better lighting, more supplies, as well as physical space.

EMS personnel may be providing airway management on the bathroom floor, on a crowded sidewalk with multiple onlookers, in a wrecked vehicle, or in the back of the ambulance. The key to a successful EMS airway is to remember one's training while being flexible and able to improvise.

You will find that the tools available for the EMS personnel vary greatly by level of training as well as by system and company. Most EMS personnel do not have access to RSI, so intubation and some adjuncts can be done mainly on patients who no longer have a gag reflex. This leaves a large group of patients who require oxygenation and ventilation yet who cannot be intubated in the field. An airway adjunct often will be used and breaths assisted with a bag-valve-mask (BVM) until arrival at the hospital or the patient either improves or loses his or her gag reflex to allow for intubation. There is the possibility of a conscious, nasal intubation mainly in the setting of a very cooperative patient with flash pulmonary edema; however, as many systems are now providing CPAP to their paramedics, nasal intubations have become increasingly rare.

Below you will see what is available to EMS personnel. Remember, you will not find all options in every ambulance, so familiarize yourself with what is available at the start of your field shift.

The Airway Bag

- **Suction:** There is often a portable suction in the airway bag or a separate bag in addition to a standing unit in the ambulance. This is a wonderful invention allowing suction for airway management anywhere a patient may be found: on the sidewalk, the edge of a mountain, or in the living room.
- **Various sized ET tubes:** Paramedics are equipped to intubate neonates to 100-year-old patients. Each ambulance should be equipped with all tube sizes.
- **Nasal cannula (NC):** Available to all EMS providers.
- **Nonrebreather (NRB):** Available to all EMS providers.
- **Neb Mask:** Who can use nebulizers varies greatly depending on the EMS system you are in. Some places, EMTs can give

albuterol nebulizers to known asthmatics only. There are other systems where EMTs cannot give any nebulizers, or saline only for a croup patient.

- **In-line Nebulizer:** To provide nebs to intubated patients. May be limited to critical care / flight crews.
- **Mac and Miller blades** of various sizes.
- **Colormetric CO2 detector:** This helps verify placement after intubation. The detector should turn from purple to gold if ET tube is in the trachea. This is only used initially after intubation. Less reliable than capnography.
- **End-tidal CO2 monitor:** Used for confirmation of initial tube placement and to monitor CO2 values throughout the transport. Waveform capnography is generally preferred to value-only capnometry.

Airway Adjuncts

- **Oropharyngeal Airway (OPA):** Inserted through the mouth to help prevent the tongue from falling back. These adjuncts only work with patients without a gag reflex. Sometimes you will see a paramedic use an OPA to "test" if the patient has a gag reflex prior to attempting intubation. Available to all levels of training. For a cardiac arrest patient, this is the primary airway management for an EMT.
- **Nasopharyngeal Airway (NPA):** Inserted through the nose

- great for obtunded patients. These should not stimulate a gag reflex. Available to all levels of training.

Advanced Airways

- **Endotracheal Tube** (ET Tube)
- **Nasotracheal Tube:** These are for awake and breathing patients who require advanced airways. They are exceedingly rare, especially with CPAP becoming more common on ALS ambulances.
- **Laryngeal Mask Airway (LMA):** You may be familiar with these in the OR. The LMA has an airway tube that connects to an elliptical mask with a cuff. When the cuff is inflated, the mask conforms to the anatomy with oxygen delivering portion of the mask facing the space between the vocal cords. After correct insertion, the tip of the LMA laryngeal mask sits in the throat against the muscular valve that is located at the upper portion of the esophagus.
- **Combitube:** Also known as the double-lumen airway, this is a blind insertion airway device. It consists of a cuffed, double-lumen tube that is inserted into the patient's airway, facilitating ventilation. Inflation of the cuff allows the device to function similarly to an ET tube and usually closes off the esophagus, allowing ventilation and preventing aspiration of gastric contents.

- **King LT:** Also known as the laryngeal tube. Comes as either a single lumen or double lumen, with the second lumen allowing access for an OG tube to aspirate gastric contents. This is also a blind insertion airway device. With balloon inflated, the esophagus is closed off protecting the airway from aspiration.

CPAP: This is becoming more common to find on ALS ambulances. Usually used for CHF exacerbations and flash pulmonary edema, but also used in some asthmatics or COPD exacerbations.

Ventilators: These are typically found on ALS transport ambulances. They have limited settings (typically only rate and tidal volume), but are quite small and compact. Great for inter-facility transports.

The Difficult Airway

- **Bougie:** You may be familiar with these from the ED. A bougie is a long, flexible plastic stylet with an angle at the end used to facilitate difficult intubations. It can be placed into the trachea when only the epiglottis may be seen. By placing the angled end of the device in first, the tip can be felt “bouncing” over the tracheal rings, and then an ET tube can be advanced into the trachea over it.

- **Needle Cricothyrotomy:** Not all paramedics are authorized to use this skill; however, it is more common as a backup airway than a surgical cricothyrotomy. This protocol varies widely from system to system. The procedure itself varies greatly as well, depending on the system and the supplies available.

- **Surgical Cricothyrotomy:** This tends to be found in more advanced EMS systems, and requires advanced training for paramedics. This procedure is typically found in systems that also allow RSI.
- **RSI:** Rapid sequence intubation is only found in more advanced systems. It requires advanced training and medical oversight, and its use in the field is controversial, with mixed outcomes. The indications, medications, and protocols for RSI will be different in each system.
- **Needle Decompression:** All paramedics receive training in needle decompression. This procedure is allowed in most systems for suspected tension pneumothorax.

CHAPTER 21

Termination of Resuscitation

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DNR laws vary by state, and appropriate documentation must be presented to EMS personnel on arrival.

TABLE

When to terminate resuscitation

Obvious death	No pulse AND No spontaneous respirations AND Fixed pupils AND at least one or more of the following: Rigor mortis, Decapitation, Decomposition, Dependent lividity
Blunt Traumatic Cardiac Arrest	No pulse AND No spontaneous respirations AND No shockable rhythm AND No organized cardiac activity (i.e. asystole, PEA < 40 bpm)
Penetrating Traumatic Arrest	No pulse AND No spontaneous respirations AND Fixed pupils AND No spontaneous movement AND No organized cardiac activity (i.e. asystole, PEA < 40 bpm)

Source: State of Oklahoma 2014 Emergency Medical Services Protocols. http://www.oudem.org/ems-protocols/

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