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HazMat Medicine and the HazMat Medic

Introduction

The late 1950s and into the early 1960s brought innovation to prehospital care as we know it today. These were the "wild west" days of a new concept called EMS (Emergency Medical Services). Many early pioneers of EMS had the vision to recognize that the lifesaving efforts typically done in the hospital setting could be accomplished in the field.

Because of the death of his daughter, Dr. Safar trained and organized one of the first prehospital EMS services in the country. While working in Pittsburg, he rigorously trained a group of ambulance attendants over nine months and in 1968, put these highly trained prehospital care providers to work. These ambulance attendants operated out of Pittsburgh's Presbyterian and Mercy Hospitals. They were instructed to manage airways, start IVs, deliver babies, and interpreted EKGs. They were known as the Freedom House Ambulance Crew. They were indeed the first civilian-trained paramedics in the country.

In 1974, the University of Pittsburg received a grant from the U.S. Department of Transportation to create a curriculum for nationwide emergency medical services. Dr. Safar and Dr. Nancy Caroline developed the standards for education, training, ambulance design, and specialized equipment.

A few innovations that occurred simultaneously contributed to a new standard for prehospital medical care. Dr. Karl Edmark perfected the heart defibrillator, giving rise to the Seattle Fire Department Medic One, a rescue program in 1970. At the same time, the revolutionary "LifePac" was being developed by Dr. Peter Safar from Pittsburg. Dr. Safar and Dr. James Elam developed the understanding and application of what was called the ABCs (Airway, Breathing, and Circulation) of CPR (Cardiopulmonary Resuscitation). All of these developments contributed to the foundations of EMS and the new emerging field of prehospital care.

Meanwhile in Florida, an electrical engineer-turned anesthesiologist, Dr. Eugene Nagel was looking at the fire department as a community resource to provide initial prehospital care. He convinced the Miami Fire Department, because of their strategic locations within the community, to have specially trained firefighters with these new lifesaving techniques and equipment to respond to medical emergencies. Radio communication equipment was provided so that the field providers could talk directly to a physician in the hospital and receive critical guidance at a medical emergency. In 1964, Dr. Nagel became the medical control officer (Medical Director) for the City of Miami Fire Department.

Hazardous Materials Medicine: Treating the Chemically Injured Patient, First Edition.
Richard Stilp and Armando Bevelacqua.

Other leaders in this field were Walt Stoy, PhD, for his contribution of education materials and systems design, and Fire Chief Jim Page, a Battalion Chief with the Los Angeles County Fire Department and founder of JEMS (Journal of Emergency Medical Services) Magazine. Chief Page paved the way for development of EMS as a discipline. He also served as a technical consultant to the TV show "Emergency." All had a hand in developing field personnel providing advanced prehospital care that later held the title of "paramedic."

In the 1970s, the television show named "Emergency" started to play on Saturday evenings. The show featured emergency calls of all types but focused on emergency medical calls. The two lead actors portrayed the paramedic/firefighters Jonny Gage and Roy Desoto. These two treated everything from trauma patients involved in a car accident and rattle snake bites to cardiac arrest. This show was a great propelling force to bring advanced prehospital life support to every community in the United States. The viewing audience witnessed what could be accomplished by well-trained and skilled paramedics. The public's expectation that ambulance attendants could save lives before the patient reached the hospital increased across the nation and raised the bar for prehospital medical care.

Both of the authors of this book became paramedics in the 1970s. In the early days of EMS, many agencies struggled to get enough paramedics trained to provide these advanced skills. Training standards were not consistent across the nation and largely depended on what the local physicians wanted their prehospital providers to know and what skills to perform. A paramedic in the City of Chicago was different than a paramedic trained in Miami. In fact, in some areas of the country, paramedics were called EMT IIs and not paramedics at all.

As this medical specialty grew in popularity, new radio systems were being introduced that allowed prehospital providers the opportunity to talk to an emergency room physician and send an EKG tracing over the radio waves. Cardiac defibrillators became more portable. Suddenly, the role of the advanced life support provider became more technical and required more knowledge to provide the best prehospital care possible.

At almost the same time, the field of hazardous materials response began to take root. There were more and more industrial accidents involving chemicals occurring both in facilities and along transportation routes. Highway crashes and train derailments often made the news because of the fires, explosions, injuries, and deaths that they caused related to the hazardous cargo.

Just as fire departments welcomed the new field of emergency medicine, they also embraced the field of hazardous materials emergency response. It would seem logical that there would be a blending between the two specialties that had found their way into the fire service. But that has not been true in the past. Seldom was there a focus of hazardous materials exposures being a subject of emergency medical training.

The paramedic curriculum has always included exposure to carbon monoxide and sometimes even went as far as teaching the pathophysiology of pesticide poisoning, but that was about it. Those EMS agencies, whether they are fire department based or not, found themselves responding to industrial, farm, highway, and railroad incidents where victims were contaminated and sick from chemical exposures. Many times, these victims were being swept up from their location and transported to the hospital without the thought of decontamination, causing injury to both the prehospital care providers and the hospital staff.

But worse than that was the injury suffered by the victim. Even today, there existed a great lack of knowledge of chemical exposure injury by both the prehospital providers and the emergency department staff. This has led to victims suffering and even dying because of a lack of appropriate care. None of these providers received adequate training to treat a victim suffering from acute chemical exposure and the resulting injury. Instead of embracing this field, it was pushed aside because it was either too technical, required too much training, or just did not happen enough to be concerned about.

The regional poison control centers across the nation were put in place to assist with these situations. They are fairly quick to respond and will send critical information to the hospitals to assist in the care of these patients. Many times, the centers are contacted by the emergency physicians, but unfortunately, too often this important step is missed by the physician, and needed information is not obtained.

Rapidly identifying the injury and providing appropriate treatment for the chemical injury will reduce the recovery time and will save lives but is often an afterthought. Although the regional poison control centers provide factual and detailed information, any expected delays in the information will ultimately delay the treatment and may lead to a poor outcome or long recovery time. Basic knowledge of chemical exposures and an understanding of how physiology may be affected is critical to providing quick and efficient treatment.

The premise for this book and the subject of chemical exposure and injury has been a career-long venture for the authors. The field of hazmat medicine has been their passion for many years. Their focus has always been to train both prehospital personnel and hospital care providers to a level where they can confidently assess and treat the victims of chemical exposure. The authors have learned from real-life experience, reviewing case studies, and conducting research to train health care providers to a level of care expected by their customers (see Figure 1.1).

Case Study – Sarin Attack in the Tokyo Subway

On March 20, 1995, the religious-based terrorist organization call the Aum Shinrikyo, under the direction of their leader Shoko Asahara, conducted an attack in the political district of Tokyo. Plastic bags filled with Sarin (a viscous liquid that vaporizes) were used to deploy the nerve agent poison that affected 15 different subway stations and trains. At the time, this was the largest terrorist attack ever carried out. In total, over 6000 victims were affected and 19 died.

Shortly after the Sarin was released into the subway cars, emergency calls began to come into the call center. In total, 1364 EMTs and 131 ambulances responded to 15 different

Figure 1.1 All emergency responders/receivers should understand the consequences of chemical exposure and injury. Rapid diagnosis and treatment is necessary for positive outcome and rapid recovery.

subway stations. At the time, the EMTs working in Tokyo were advanced practice EMTs and were trained in advanced airways and IV therapy but were required to receive direct orders from a physician to do either. Because of the ongoing disaster, physicians were not available to provide those orders and as a result, only one patient received an advanced airway and IV. No other advanced life support was conducted outside of the hospital.

Although some of the victims died or had more serious signs and symptoms that required care in the hospital, most of the 6000 only complained of eye pain, dim vision, and headache related to miosis caused from low-level exposure. Those treated in the hospital were related to breathing, somatic, and cardiac issues.

The hazardous materials response team was managed within the Tokyo Metropolitan Fire Department (TMFD). The team had advanced capabilities including infrared gas analyzer and gas chromatograph-mass spectrometer (GCMS). The police department has similar equipment but only had select individuals trained to use the equipment and did not maintain a hazardous materials response team.

The first call for assistance came into the dispatch center at about 8 a.m. At about 10 a.m., the TMFD identified the chemical offender as acetonitrile (methyl cyanide). This analysis was incorrect. At about 11 a.m., the police department correctly identified the material as sarin using their own GCMS.

The after-action reports completed well after the incident found several major points for concern. First, there was a lack of training and equipment available for a chemical response including the absence of prehospital decontamination which led to the secondary contamination and injury to both emergency responders and hospital staff. 135 EMT alone developed acute symptoms and received medical treatment at the hospital. Second, the EMTs were hindered in the care of the victims because, although they were trained and equipped, the EMTs were unable to provide advanced care unless given direct permission by a physician but all physicians were overwhelmed in the hospital and unable to provide the required permission. Finally, it was determined that triage in chemical disasters, including nerve agents, is of limited use since delayed symptomatology that can be consequential and normal data points were developed for trauma patients.

When this incident took place in 1995, the hazmat medical program provided in this book was well underway. This incident provided the authors with addition motivation to prepare for all kinds of chemical events. In fact, the authors of this book took many lessons learned from terrorist activities around the world and authored the book "Terrorism Handbook for Operational Responders." This became the first Terrorism-based book for emergency responders in the United States and was published well before the terrorist attack on September 11, 2001 and the Anthrax incidents that followed. Now, almost 30 years later, this program addresses all of the shortcomings that were found in Tokyo and other significant chemical/biological incidents. Since that time, there have been many chemical incidents that have caused extensive injuries and deaths. All have provided evaluation points to improve the information found in this text. It has always been the author's goal to prepare and teach hazardous materials medical information so the effects from chemical incidents of all types are reduced.

History

In the 1980s, when we first envisioned this field of study and began developing and presenting coursework to our fellow paramedics, we found that some criticized us, believing that treating chemically injured patients was more of a Ghostbusters operation and there are not enough of these patients to truly make a difference. Others recognized the need for the training, embraced the additional knowledge and skills, and adopted much of what they learned into their responses.

With greater training and knowledge of chemical incidents, prehospital responders began recognizing that there were many more chemically injured patients than they had previously thought. Many of the incidents were reported to dispatch centers as a general illness or injury not as a report of chemical exposure.

The authors found that many incidents that were dispatched as normal EMS responses were really related to chemical exposures. One example involved two different cases involving elderly women who lost consciousness during a hair-dying procedure. In both of these cases, a hair dye was placed on the victim's head, and after the dying procedure was complete and the victim's hair was being washed in a salon sink, they lost consciousness. These incidents occurred only three days apart involving the same beautician. When the second incident took place, an investigation revealed that the hair dye, made outside of the United States. contained a high nitrite concentration. The nitrite concentration combined with the elderly patients with poor circulation contributed to the loss of blood pressure and loss of consciousness. After years of presenting these cases to students, many have reported back that they have experienced similar emergency calls involving hair dye.

Another incident that has been misdiagnosed for years, especially in Florida, is the emergency call for assistance to a patient with heat stroke. Typically, when emergency services arrive, they find a patient unconscious after working outside on the lawn. The patient's skin is not significantly hot, and their blood pressure is abnormally low. In some of these cases, there is evidence of fertilizer stuck on the patient's legs from the knees to the ankles, which is often ignored. The EMS responder starts treatment for a heat-related injury not understanding that the loss of consciousness is not related to heat exposure.

Fertilizers are rated according to its content and contain three numbers. The first number is the percentage of Nitrogen, the second is the percentage of Phosphorus, and the third the percentage of Potassium. Those fertilizers with a high first number are especially toxic. For example, 20-3-3 contains 20% nitrogen. The nitrogen is often sodium nitrite or similar chemical.

In many of these cases where homeowner have spread high nitrogen fertilizer without protecting their sweaty skin, the exposure causes a complete loss of vascular tone resulting in a loss of blood pressure and consciousness. This is misdiagnosed as a heat-related injury instead of a chemical exposure leading to mistreatment. The authors have presented these cases during classes over the years. Again, many students have returned to us stating that this scenario has happened to them as well, but because of their recent hazmat education, they have been able to diagnose and treat appropriately.

The decision to take on the task of developing a hazardous materials toxicology-based program led us to have many spirited discussions with our medical director, personal conversations with other health care professionals. and evaluating our own experiences. Using our teaching and emergency response experiences, we created a program that would benefit our department, our team, and ultimately brought the approval of our medical director. We knew that we were venturing into an area of study that had not been attempted before in the prehospital community. Little did we know that it would eventually become a national program of study.

We did not enter into this endeavor without appropriate backgrounds. By the late 1980s, both of us already had more than a decade of experience serving as field paramedics.

Both instructed paramedic school at the local college and had taught advanced classes in ACLS, pharmacology, pathophysiology, trauma life support, and were serving as hazmat technicians on our department's hazmat team. With the blessing of both our department and our medical director Dr. Robert Duplis, we started down this path of developing the first hazmat Advanced Life Support program and course in the nation.

Over the years of actual scene response, teaching hazmat medicine, writing, and researching, we have had the opportunity to generate many operational procedures. Throughout those years, numerous departments and agencies have requested our policies, procedures, and our medical SOPs to use in their agencies. Even State agencies have incorporated our policies and procedures into their medical systems. In one case, we were requested to participate in the development of a national evidence-based protocol for response to victims of weapons of mass destruction and become reviewers of national curricula (Figure 1.2).

That leads into the present day and this text. Although there have been several other books published in this area of study, including an earlier book published by the authors of this book, this one is the most complete text available. This text represents lessons learned, years of research, review of many case studies, and years of teaching and guiding other agencies on the development of hazardous materials medical programs. We have always believed that if you want to truly understand and function at a high level then, you must teach. We have learned a lot over the past 40 years of response and instruction. A good deal of this learning, from our perspective, came from our students and their experiences. Through them, we have learned and matured in our thoughts and response concepts.

We understand and teach what we know works, both in the field and in the emergency department. From the beginning, we have focused on what can be accomplished in the field. We begin with a quality assessment to form a differential diagnosis, then follow that with appropriate treatments based on the assessment findings and, when possible, determination of the offending chemical.

Through the response and review of many emergency incidents and exercise design and evaluations, we identified both the extent and limitations of field practice. Of course, the emergency departments will always have the ability to take treatment further than a field paramedic can. For example, many toxidromes could be addressed in this text, but the application of treatment of these toxidromes is beyond the capability of field advanced life support trained personnel and many hospital emergency departments. Some require extensive

Figure 1.2 The hazardous materials medical technician program emblem has changed through the years. These emblems represent the program from 1990 to present.

laboratory testing and long-term care or chelation therapies. These do not have a place in the field or the emergency department.

There exists a fallacy that training for chemically exposed patients should only be provided to those paramedics that support the hazardous materials teams. This is misleading as most chemical exposures take place with individuals not associated with a hazardous materials incident. There also exists the thought that emergency department medical providers do not need the training because resources are at their fingertips to guide them in the treatment process. After several experiences which resulted in unnecessary death, we have found that this is also not true. Both prehospital care providers and hospital emergency department medical providers need training and education on both assessment and treatment for the chemically injured patient.

For example, one of our case studies involves a 12-year-old girl who was exposed to 70% hydrofluoric acid. The father had purchased the acid for his pressure cleaning company because of its ability to remove rust stains from the stucco on buildings. His daughter knocked over a 1 gal jug wetting the grass with the acid. The 12-year-old then slipped in the wet grass, exposing both legs, buttocks, and back. The injured girl was taken to the hospital, where the father carried her into the hospital in his arms, handed her to a nurse, who subsequently handed her to a physician who placed the girl on the bed. By this time, the young 12-year-old was unconscious.

Complaints of burning arms by the father, nurse, and physician soon followed. No one in the Emergency Department understood the effects of hydrogen fluoride. They only understood that it burned their skin and eyes. Unfortunately, a bolus or two of calcium gluconate or calcium chloride may have saved the girl's life. A lack of awareness and training caused the misconception that hydrofluoric acid was similar to hydrochloric acid. Both cause injuries at the site of contact, but one greatly differs from the other in systemic toxicity. This demonstrates the importance of training in chemical exposures at all levels of the emergency medical chain of response.

Events

Although true hazardous material incidents do not occur every day, what is seen frequently is the personal misuse of chemicals both in the household and in the workplace, causing exposures. These are typically not classified as hazardous materials incidents. Most of the patient exposures that are treated by emergency responders do not come from a dispatched hazardous materials incident. Instead, the emergency response was dispatched as some kind of general medical call, and it was not until the EMS providers arrived and found that an exposure to a chemical was responsible for the resulting symptoms.

Unfortunately, most emergency responders do not have appropriate training to deal with these patients. Not only do these patients often present a secondary hazard to the health care provider, but their recovery is dependent on how they are treated immediately after the exposure. Many times, the lack of understanding and the continued tissue damage related to the exposure causes patients to decompensate while in route or while awaiting lab results in the hospital emergency room.

This text was developed to provide both the knowledge and skill necessary to assess, diagnose, and treat an acutely chemically injured patient. In addition, the materials presented in this book will provide background, physiology, and logic to the assessment and treatment process.

In some incidents, it will be easy to determine the chemical and route of exposure to cause the injury. A chlorine leak at a water treatment facility is one of those examples. These are not difficult to determine, and responders are rarely led in the wrong direction. But, when an employee of a chrome plating company is found unconscious in the shop, and there is no clear cause for the incident, a detailed assessment must be completed to determine if the patient's illness is due to exposure or a medical cause. Today, emergency responders and emergency department nurses, and physicians have equipment immediately available that can help with the determination of the cause. And if not, through a detailed focused assessment, the care provider can be led into a differential diagnosis strategy.

Situational Assessment Continuum

Through many years of evaluating case studies and participating in emergency responses related to chemical exposures, we have developed a Situational Assessment Continuum (SAC) model to follow in both assessing the patient and the scene. This model has three components, (as seen in Figure 1.3), that can be evaluated on an emergency scene. Contained in each of these components is critical information that will assist the responder in developing a diagnosis and treatment plan. The three components are:

Patient presentation (Exposure and toxidromes)
Event conditions (Scene evaluation)
Scene assessment (Hazard identification)

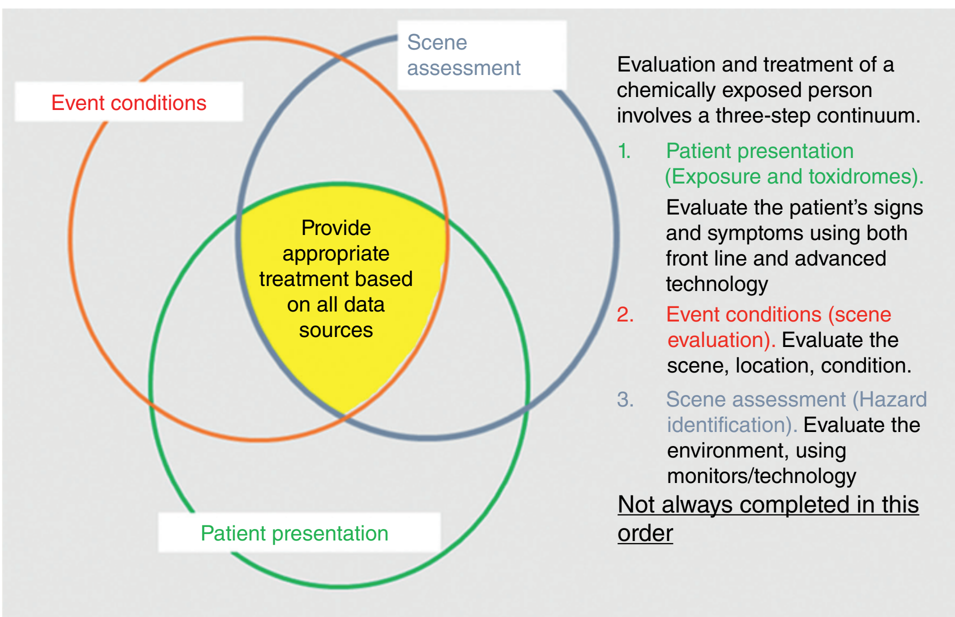

Figure 1.3 The Situational Assessment Continuum includes the evaluation of three critical components after a chemical exposure.

Every scene and situation is different, and it is realized that not all three components are always available. Take for example, the patient who walks into an emergency room or fire station and states that he/she has been exposed to some chemical and is now having difficulty breathing. In this case, there are no components of the environment or scene to evaluate to assist in determining what kind of chemical may be involved. But can a health care provider still provide care? Absolutely, but now they are treating symptoms, evaluating the pathophysiology, and providing treatment that is guided by the known physical changes that are taking place.

The process involves three different areas of assessment to develop a full picture of the patient's state of exposure. There is no set order of this process, so information can be gathered as the assessment in each area is completed. The more information that is gathered, the more confidence a medical provider will have when treating the patient. When detailed information is received, the medical provider must be able to quickly narrow down the differential diagnosis and, in many cases, determine the exact chemical and to what degree the patient is exposed/injured. Described below are the three areas of assessment.

Patient Presentation

Although these components can be completed in any order or concurrently, the patient assessment is usually done first. The only other consideration that needs to take priority over the patient assessment would be to ensure scene safety. On a hazardous materials scene, this is an extremely important step. In a later chapter, the hazmat patient assessment, or as it is referred to in this text, the "toxidrome exam," (page 15) will be covered in detail. A good patient evaluation is paramount to providing appropriate and efficient treatment.

Event Conditions (Scene Evaluation and Size-up)

Evaluating the event involves the initial size-up of the scene. It includes any information that is gathered on dispatch, en route, and what you see when you arrive. This may include information provided by bystanders and what is witnessed upon arrivals such as smoke, chemical clouds, containers present, and type of industry. In hazmat team terms, this is referred to as "recognition and identification." In addition to the typical hazmat size-up are those external factors such as weather, personal accounts, and the activity occurring at the time of the incident. Gaining information from just the event will assist the responder in some initial thoughts on the types of chemicals that may be involved.

Scene Assessment (Hazard Identification)

This assessment is a detailed evaluation of the location of the initial injury. This includes the use of air monitoring equipment to determine the level of concentration that is present. Identifying the state of matter (i.e. solids, liquids, vapors, and gases), which gives further clues on the potential route of entry. This assessment may include air monitoring, collecting samples for analysis, or more detailed studies, depending on the circumstances. However, observation of the scene with the associated symptomology and event location all play a role in understanding the toxidrome.

Summary

Hazardous materials emergency medicine has improved over the last four decades. Advanced equipment that can be used to assist in the assessment of chemically injured patients that was previously available only in hospital ICUs are now found in the prehospital setting and used by both emergency responders and emergency department personnel. But, to use these tools to the fullest capability takes training, understanding of the diagnostic equipment, and an in-depth understanding of the physiology of the poisoning.

In addition to the improvements of equipment, there have also been great improvements in the educational base to become a paramedic. The paramedic textbooks of the 1970s included just a few hundred pages of text. This is pale in comparison to today's paramedic text of 2500 pages. Just a few years ago, nurses who were working in emergency rooms were only required to obtain a diploma or associate's degree are now required to be certified emergency nurses, and many are BS degree nurses or hold higher degrees. Emergency department physicians are now required to complete a residency in emergency medicine and are board-certified emergency physicians. The educational and skill requirements have been greatly improved since we started this endeavor and will continue to improve in future years. Many of those who, in the past, thought that hazardous materials medicine was an exercise in futility have now seen the advantage of this area of study in both paramedicine and emergency department care.

The true power of this text is that an instructor with a reasonably good EMS background and with a bit of hazardous materials response background combined with the information available in this text, can present the coursework in this area of study to prehospital and hospital emergency care providers.

We envision that the subject of hazmat medicine will become a permanent part of the national paramedic curriculum and certainly be a subject for emergency medicine in medical school. This is the goal that we have strived for, over so many years of teaching, researching, and delivering this content.