Chapter 64
Response to Hazardous Materials Incidents

Learning Objectives

- Identify training regulations regarding EMS, hazardous materials response, and contact agencies that may provide additional information
- Identify commonly used recognition and identification clues
- Identify international and DOT hazard classes

Learning Objectives (Cont'd)

- Use physical properties to assess the movement of hazardous material
- Use chemical properties to determine a chemical's hazard potential
- Identify properties used to determine a chemical's toxicity
Learning Objectives (Cont’d)

• Identify written and verbal resources that can be accessed to obtain chemical information
• Determine the safest way to approach a hazardous materials incident

Learning Objectives (Cont’d)

• Identify exclusion (hot), contamination reduction (warm), and support (cold) zones at hazardous materials/weapons of mass destruction incident and describe EMS actions performed in each zone
• Identify the types of personal protective equipment that should be used by EMS responders at a hazardous materials incident

Learning Objectives (Cont’d)

• List four Environmental Protection Agency designated levels of protection and discuss their use and the limitations of each
• Identify the procedures necessary for proper responder monitoring and rehabilitation at a hazardous materials incident
• Describe responder decontamination procedures
Learning Objectives (Cont'd)

- Discuss the need for patient decontamination and explain how it is carried out
- Describe how effective mass casualty decontamination may be carried out
- Identify the proper treatment for commonly encountered hazardous materials

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Learning Objectives (Cont’d)

- Discuss the need for early scene-to-hospital communication
- Identify ways to reduce secondary exposure risk during patient transportation
- Identify procedures that must take place at the end of an incident

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Introduction

- Hazardous material
  - Solid, liquid, or gas capable of harming people, environment, or property
  - Found in:
    - Industrial locations
    - Swimming pools
    - Hospitals
    - Agricultural areas
    - Homes
EMS Responders

- In contact with exposed patients
- Adequate management may require changes in normal response practices
- Hazardous materials harm
- Heat stress to PPE

Training Requirements

- OSHA, EPA
  - Mandatory safety procedures for responders
  - Hazardous Waste Operations and Emergency Response (HAZWOPER) covers safety of responders

Training Requirements (Cont’d)

- HAZWOPER training standard
  - Awareness
    - Recognize hazardous materials
    - Isolate area
    - Call for assistance
    - Training objectives
Training Requirements (Cont’d)

- HAZWOPER training standard
  - Operations
    - Operate in a defensive manner
    - Do not make direct, intentional contact with substance
    - Training objectives

Training Requirements (Cont’d)

- HAZWOPER training standard
  - Technician
    - Make direct, intentional contact with spilled material to decrease problem
    - Training objectives

Training Requirements (Cont’d)

- HAZWOPER training standard
  - Specialist
    - Specialized, focused knowledge about an aspect of response
    - Training objectives
  - Incident command
    - Takes control of incident and direct response operation
Training Requirements (Cont’d)

• National Fire Protection Association
  ➢ Voluntary training competencies
    ➢ Level 1
      ➢ Patient care in cold zone
    ➢ Level 2
      ➢ Patient care using PPE in warm zone

Hazardous Materials Recognition

• Presence not always apparent
  ➢ Multiple patients with similar symptoms
  ➢ Dead animals, vegetation, lawns
  ➢ Numerous surfaces with oily films or droplets
  ➢ Recognition and identification of materials involved most important

Hazardous Materials Recognition (Cont’d)

• Transportation of hazardous materials
  ➢ Governed by U.S. DOT
    ➢ Requires:
      ➢ Containers
      ➢ Markings
      ➢ Mode of transportation
      ➢ Documentation needed
Hazardous Materials Recognition (Cont'd)

- Transportation of hazardous materials
  - Transportation containers
    - Nonbulk
      - Smaller, individual packages
    - Bags and sacks: solids
    - Bottles: solids, liquids
    - Drums: solids, liquids

- Transportation of hazardous materials
  - Transportation containers
    - Carboys
    - Cylinders

- Transportation of hazardous materials
  - Transportation containers
    - Bulk containers
    - Large container and tanks
    - Intermodal tank containers
    - Ton cylinders
    - Radioactive materials protective packaging
    - Cargo tanks
Hazardous Materials Recognition (Cont'd)

- Transportation of hazardous materials
  - Transportation containers
    - MC 306
      - Elliptical
      - Up to 9000 gallons
      - Liquid lighter than water

Hazardous Materials Recognition (Cont'd)

- Transportation of hazardous materials
  - Transportation containers
    - MC 307
      - Circular
      - 5000–6000 gallons
      - Liquid heavier than water

Hazardous Materials Recognition (Cont'd)

- Transportation of hazardous materials
  - Transportation containers
    - MC 311
      - Pressurized liquids or gasses
    - MC 338
      - Cryogenic tank
      - Heavily insulated
Hazardous Materials Recognition (Cont'd)

- Transportation of hazardous materials
  - Tube trailer
  - Rail cars

Hazardous Materials Recognition (Cont'd)

- Transportation of hazardous materials
  - Hopper cars
  - Nonpressurized liquid
  - Pressurized

Hazardous Materials Recognition (Cont'd)

- Transportation of hazardous materials
  - Pipelines
    - Are also transportation containers
    - May carry different products at different times
Hazardous Materials Recognition (Cont'd)

- Transportation of hazardous materials
  - hazard classes
    - DOT requires containers be marked
    - International hazard classes
    - Listed in North American Emergency Response Guidebook

Hazardous Materials Recognition (Cont'd)

- Transportation of hazardous materials
  - Placards
    - Color
    - Symbol at top
    - International hazard class at bottom
  - Four-digit identification numbers

Hazardous Materials Recognition (Cont'd)

- Transportation of hazardous materials
  - Hazard classes
    - Class 1: explosives
    - Class 2: gases
    - Class 3: flammable, combustible liquids
    - Class 4: flammable solids
    - Class 5: oxidizing substances
    - Class 6: poisonous, infectious substances
    - Class 7: radioactive substances
    - Class 8: corrosive material
    - Class 9: miscellaneous hazardous materials
Hazardous Materials Recognition
(Cont'd)

- Transportation of hazardous materials
  - Shipping papers must accompany hazardous materials
  - RQ identification

- Transportation documentation

Hazardous Materials Recognition
(Cont'd)

- Storage and handling of hazardous materials

  - Fixed facilities
    - Bulk–nonpressure
    - Bulk–low pressure
    - Bulk–high pressure

Hazardous Materials Recognition
(Cont'd)

- Fixed facility marking and labeling systems
  - NFPA 704 most popular
    - Provides information on material inside tank, building, laboratory
    - Diamond-shaped sign with four quadrants
      - Red: fire hazard
      - Blue: health hazard
      - Yellow: reactivity
      - White: other information
      - Use 0–4 to indicate hazard, 4 is severe
Hazardous Materials Recognition (Cont'd)

- Storage and handling of hazardous materials
  - Labels on containers
    - OSHA Hazard Communication Standard: HAZCOM
    - Hazardous Materials ID System
      - Product name
      - Protective equipment needs
      - Health hazards
      - Flammability
      - Reactivity hazards
Hazardous Materials Recognition (Cont'd)

- Storage & handling of hazardous materials
  - Labels on containers
    - EPA Hazardous Waste Label
      - Name of waste
      - ID numbers
      - Name of waste generator
      - Accumulation start date

Hazardous Materials Recognition (Cont'd)

- Storage and handling of hazardous materials
  - Labels on containers
    - EPA requires labels for pesticides
      - Name of pesticide
      - Signal word indicating toxicity
      - EPA registration number
      - Precautionary statement
      - Hazard statement
      - Names of active ingredients

Hazardous Materials Recognition (Cont'd)

- Use of recognition and identification clues
  - Occupancy and location
    - Knowledge of containers within community
  - Containers
    - Knowledge of containers
    - Provide clues of state of matter
  - Markings and colors
    - NFPA 704
    - Railcars must have name of substance stenciled on side
Hazardous Materials Recognition (Cont'd)

- Use of recognition and identification clues
  - Placards and labels
    - May not be present due to low quantities
  - Shipping papers
    - Must get close to substance to retrieve
  - Senses
    - Most senses require proximity to hazard
    - Visual signs
    - Vapor clouds, liquid spills, dead people

Hazard Assessment

- Agent pattern and potential outcome
  - Predict exposure and level
  - Anticipate potential injuries

Hazard Assessment (Cont'd)

- Chemical movement
  - Stage safely
  - Predict exposure
  - State of matter has impact on type of victim exposure
Hazard Assessment (Cont'd)

- Chemical movement
  - State of matter
    - Vapors
    - Liquids and solids
    - Melting point
    - Boiling point
    - Specific gravity
    - Water solubility
    - Volatility
    - Vapor pressure

- Must know water solubility and vapor pressure properties
  - Inhaled chemicals with lower solubility can result in lower airway symptoms
  - Chemicals with high vapor pressure result in increased inhalation risk
**Hazard Assessment (Cont'd)**

- Chemical movement
  - Boiling liquid expanding vapor explosion
    - When pressurized containers with liquids are suddenly breached, liquid rapidly boils and expands
    - If flammable, fireball results
  - Vapor density
    - Weight of volume of pure gas compared with weight of equal volume of pure dry air
    - Heavier air vapors create greater risk of exposure and fire if reach ignition source
Hazard Assessment (Cont’d)

- Hazard potential
  - Flammability
    - Flashpoint
    - Auto ignition point
    - Lower flammable limit
    - Upper flammable limit
    - Flammable range

Hazard Assessment (Cont’d)

- Hazard potential
  - Corrosivity
    - Damages human tissue or highly corrosive to steel
    - Acids and bases
    - Corrosive vapors cause inhalation exposure and tissue damage

Hazard Assessment (Cont’d)

- pH scale
  - More acidic
    - 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14
  - More basic
    - Extremely corrosive
    - Extremely corrosive
Hazard Assessment (Cont'd)

- Hazard potential
  - Reactivity
    - Interaction produces heat, increased corrosivity, increased toxicity
    - Water-reactive materials
    - Air-reactive materials
    - Pyrophorics
    - Oxidation ability

Hazard Assessment (Cont'd)

- Hazard potential
  - Radioactivity
    - Spontaneous disintegration of unstable nuclei with emission of nuclear radiation
    - Produces changes in matter
    - Alpha particles
    - Beta particles
    - Gamma rays
    - Neutron radiation
    - Protection

Hazard Assessment (Cont'd)

- Hazard potential
  - Toxicology
    - Dose/response relation
    - Toxic effects of exposure estimated to exposure level
    - Lethal dose system based on animals
    - Potentially dangerous exposure levels
    - Threshold limit value
    - Permissible exposure limit
    - Immediate dangers to life or health concentrations (IDLs)
Hazard Assessment (Cont’d)

- Hazard potential
  - Toxicology
    - Duration of exposure
      - Shorter exposure, less absorbed, lower response
      - Acute
      - Chronic

Hazard Assessment (Cont’d)

- Hazard potential
  - Toxicology
    - Routes of exposure
      - Inhalation
      - Ingestion
      - Skin or eye exposure
      - Injection

Hazardous Materials References

- North American Emergency Response Guidebook
  - Placard
  - Chemical name
  - Four-digit ID number
Hazardous Materials References (Cont'd)

Material safety data sheets (MSDS)
- Readily available for each chemical at worksite
- OSHA required information
  - Chemical name
  - Physical data
  - Chemical ingredients
  - Fire and explosion hazard data
  - Health hazard data
  - Reactive data
  - Spill or leak procedures
  - Special protection and precaution information

Computer-aided management of emergency operations (CAMEO)
- EPA database
  - Base program has chemical-specific information for:
    - Chemical identifiers section
    - Hazards section
    - Response recommendations
    - Physical properties
    - Regulatory information
    - Alternate chemical names
Hazardous Materials References (Cont'd)
- Telephone references
  - Available 24/7
  - Possible mistakes when transcribing information
  - Chemical Manufacturers Association
  - Regional Poison Control Center

Safe Response Practices
- Initial response
  - First priority: protect responders
  - Safe zone
  - Establish command
  - Set up ICS
  - No rescues from contaminated areas attempted until chemical identified
  - Screen bystanders and witnesses for exposure
  - Consider evacuation needs

Safe Response Practices (Cont'd)
- Scene management
  - Security
    - Limit access to properly trained response personnel
  - Hot zone
    - Exclusion zone
    - Contamination exists
    - Rapid patient removal
    - If trapped, stabilization and care
    - Airway control
    - Isolation of airway
Safe Response Practices (Cont’d)

- Scene management
  - Warm zone
    - Medical care during decontamination
    - ABC/DE
    - Airway
    - Breathing
    - Circulation (hemorrhage control)
    - C Spine stabilization
    - Decontamination
    - Evaluate for systemic toxicity
    - O₂ administration

Safe Response Practices (Cont’d)

- Scene management
  - Cold zone
    - Ensure adequate decontamination
    - Transfer patient from decontamination personnel to medical caregivers
    - Limit contamination spread
    - Place patient on clean backboard, stretcher
    - Perform basic, advanced life support as required

Safe Response Practices (Cont’d)
Safe Response Practices (Cont’d)

- Safety plan
  - Managed by incident-specific safety plan
  - User friendly
  - Guide for resolving incident
  - Changes as scene conditions change

Personal Protective Equipment

- Purpose: shield from chemical, physical, biological hazards
- PPE based on responder involvement

Personal Protective Equipment (Cont’d)

- Respiratory protection
  - Air-purifying respirators
  - Positive-pressure SCBA
  - Positive-pressure supplied-air respirators
  - Factors:
    - \( \text{O}_2 \) concentration in area
    - Identifying concentration of substance
    - Chemical and physical properties
    - Warning properties of substance
    - Area in which responders must operate
    - Specific tasks to be completed
Personal Protective Equipment (Cont'd)

- Chemical protective clothing
  - Vapor protective clothing
    - Highest protection against skin destruction and absorption
    - Fully encapsulating
    - Highest degree of respiratory protection
  - Chemical splash protective clothing
    - Protects against liquid splash or particulates
    - Limited vapor protection

Personal Protective Equipment (Cont'd)

- Chemical protective clothing
  - EPA designations
    - Level A
      - Highest level of protection
      - Includes positive pressure SCBA
      - Fully encapsulating
Personal Protective Equipment (Cont'd)

Chemical protective clothing

- EPA designations
  - Level C
    - When type of airborne substance is known
    - Concentration measured
    - Criteria for air-purifying respirator is met
    - Skin exposure unlikely
    - Full face air-purifying respirator
    - Chemical-resistant clothing
Personal Protective Equipment (Cont'd)
- Chemical protective clothing
  - EPA designations
    - Level D
    - Work uniform
    - Turnout gear
    - Not worn where skin or respiratory hazards

Personal Protective Equipment (Cont'd)

Hazardous Material Team Support
- Preentry examination
  - Level A or B protection worn
  - Determine baselines
  - Skin for wounds, rashes, irritations
  - Mental status, gait
  - Neurological functions
  - Baseline ECG
  - Recent illness in past 72 hours
  - Prehydrate with 8–16 oz sports drink
Hazardous Material Team Support (Cont'd)

- Preentry examination
  - Denial of entry into hot zone
    - Body temperature >99.2°F
    - Pulse >110 beats/min
    - BP >150/90 mm Hg
    - Respiratory rate 24 breaths/min

- Postentry examination
  - Removal from hot zone, decontaminated, evaluated:
    - Changes in gait, speech, behavior
    - Chest pain
    - Dizziness
    - Shortness of breath
    - Weakness
    - Nausea
    - Headache

Hazardous Material Team Support (Cont'd)

- Postentry examination
  - Heat stress
    - Greatest risk to team members
    - Due to nature of chemical suit
  - Chemical exposure
    - Monitor vitals every 5–10 minutes until back to baseline
Hazardous Material Team Support
(Cont'd)

- Documentation
  - Preentry exam
  - Postentry exam
  - Treatment provided
  - Response to treatment
  - Recommendation of paramedic and IC as to ability to accept additional assignments

Decontamination

- Contamination corridor established in warm zone
  - Separate areas to decontaminate responders, patients, equipment
- Product, life threat, route of exposure, and need for decontamination identified

Decontamination (Cont'd)

- Responder decontamination
  - All personnel
  - Clothing
  - Equipment
  - Patient care equipment changed to clean equipment
  - Dry decontamination if contamination is minimal
Decontamination (Cont'd)

- Patient decontamination
  - Ambulatory patient decontamination
    - Wear PPE
    - Exit contaminated area
    - Provide shelter
    - Remove and isolate
    - Clothing
    - Jewelry
    - Shoes
    - Rinse with copious warm water
    - Baby shampoo or mild soap
    - Contacts removed when patient hands cleaned

- Nonambulatory patient decontamination
  - Wear PPE
  - Remove from contaminated area
  - Provide shelter
  - Remove and isolate
  - Clothing
  - Jewelry
  - Shoes
  - Brush off contaminants
  - Do not damage skin
  - Decontaminate head and face first
Decontamination (Cont’d)

- Patient decontamination
  - Mass casualty decontamination
  - Emergency decontamination
  - Decontaminate extremely large numbers
  - Fire apparatus or hoses
  - Fire hoses from two directions
  - Two fire engines side by side
  - Uses cold water
Decontamination (Cont’d)

- Patient decontamination
  - Should be contained if possible
  - Wading pools useful
  - Patient decontamination should not be delayed
  - Local and state officials notified if runoff cannot be contained

Treatment for Common Hazardous Materials

- Corrosives
  - Cause severe irritation or burns to skin
  - Upper airway burns and edema
  - Circulatory collapse
  - Severe skin burns
  - GI perforation
  - Hemorrhage
  - Peritonitis
  - Toxic system effects
  - Inhalation, ingestion, direct contact with skin

Treatment for Common Hazardous Materials (Cont’d)

- Corrosives (Cont’d)
  - Treatment
    - Adequate decontamination
    - Manage airway
    - Do not induce vomiting, use emetics
    - Monitor for pulmonary edema and treat dysrhythmias
    - IV at 30 mL/hr
    - Flush eyes with water, irrigate, and continue during transport
    - Cover skin burns with dry/sterile dressings
    - Do not attempt neutralization
Pulmonary irritants

- Chlorine reacts with water, forms hydrochloric acid
- Ammonia reacts with water, forms ammonium hydroxide
- Inhalation, ingestion, or skin/eye contact
- Pulmonary edema
- Hypotension
- Eye irritation
- Chemical skin burns
- May form strong alkali in respiratory system

Treatment

- Adequate decontamination
- Manage airway
- Ventilate as necessary
- Consider intubation at first sign of upper airway obstruction
- Consider bronchodilator use
- Monitor for pulmonary edema
- Monitor cardiac rhythm and treat dysrhythmias
- IV at 30 mL/hr

Pesticides

- Organophosphates and carbamates
- Among the most poisonous chemicals
- Inhalation, ingestion, skin and eye contact, skin absorption
- Cause respiratory failure
  - Chemically mediated pulmonary edema
  - Respiratory muscle paralysis
  - SLUDGE-BBM
Treatment for Common Hazardous Materials (Cont’d)

- **Pesticides**
  - Treatment
    - Adequate decontamination
    - Manage airway
    - Ventilate as necessary
    - Consider intubation at first sign of upper airway obstruction
    - Consider bronchodilator use
    - Monitor for pulmonary edema
    - Monitor cardiac rhythm and treat dysrhythmias
    - IV at 30 mL/hr

Treatment for Common Hazardous Materials (Cont’d)

- **Pesticides**
  - Treatment
    - Vasopressor if hypotensive with normal fluid volume
    - Atropine per protocol
    - Pralidoxime chloride per protocol
    - Treat seizures with atropinization and hypoxia correction
    - Succinylcholine, other cholinergic agents, and nophylline contraindicated
    - Flush eyes, continue irrigation during transport

Treatment for Common Hazardous Materials (Cont’d)

- **Chemical asphyxiants**
  - Cyanide
  - Carbon monoxide
  - Decontaminate as necessary
    - CO victims do not need decontamination
Treatment for Common Hazardous Materials (Cont’d)

- Chemical asphyxiants
  - Treatment
    - Manage airway
    - Ventilate as necessary
    - Do not induce vomiting
    - Monitor for pulmonary edema, cardiac rhythm
    - IV at 30 mL/hr

- Chemical asphyxiants
  - Treatment
    - Administer cyanide antidote kit
    - Treat seizures with diazepam or lorazepam per protocol
    - Flush with water, continue irrigation during transport
    - Consider hyperbaric O₂

Treatment for Common Hazardous Materials (Cont’d)

- Hydrocarbon solvents
  - Skin and eye irritation
  - Dysrhythmias
  - Pulmonary edema and respiratory failure
  - Seizures and paralysis
  - Brain and kidney damage
Treatment for Common Hazardous Materials (Cont’d)

- Hydrocarbon solvents
  - Treatment
    - Adequate decontamination
    - Manage airway
    - Ventilate as necessary
    - Consider bronchodilator for bronchospasm
    - Do not induce vomiting
    - Monitor for pulmonary edema, cardiac rhythm
    - IV at 30 mL/hour
    - Avoid epinephrine

Patient Transport

- Hospital communication
  - Early notification important
  - Some victims may have self-transported
  - Number of patients
  - Nature of incident

Patient Transport (Cont’d)

- Reducing secondary contamination risk
  - Ensure patient and crew protected during transport
  - Nonessential equipment removed before transport
  - Cover walls and ceiling of ambulance with plastic
  - Adequate ventilation in transport vehicle
  - Reverse isolation
  - Vomitus may contain volatile compounds
  - PPE worn during transport
Post-Incident Concerns

- Secondary contamination prevention
  - Residual contamination of equipment
  - Residual contamination of ambulance
- Incident debriefing, postincident analysis review
  - Cause assessed
  - Response procedures assessed
- Emotional stress

Chapter Summary

- Hazardous materials incident is one of the most challenging emergencies that EMS face; it involves out-of-the-norm activities such as use of PPE and decontamination
- Responders must be able to recognize the presence of hazardous materials at an incident

Chapter Summary (Cont’d)

- Responders must be able to use available references and understand the importance of chemical and physical properties when assessing hazards at an incident involving hazardous materials
- Proper approach, scene management practices essential to responder safety at hazardous materials incidents
Chapter Summary (Cont’d)

- Special training is required before responders may operate at this type of emergency
- EMS personnel must be able to select and use proper PPE if operating in warm/hot zones of hazardous materials incident

Chapter Summary (Cont’d)

- EMS responders should be able to provide the hazardous materials team with medical support and responder rehabilitation at a hazardous materials incident
- Proper decontamination of responders and patients is essential to limit harm and the chance of secondary contamination

Chapter Summary (Cont’d)

- EMS responders should have an understanding of proper treatment practices for commonly encountered hazardous materials
- Responders must understand the need for interaction with local hospitals and the need for proper transport procedures when transporting patients from the scene of a hazardous materials incident
Chapter Summary (Cont’d)

- Postincident procedures such as debriefing, analysis, and review are vital pieces of the hazardous materials response.

Questions?