Evaluation of the Downed Firefighter

INTRODUCTION

On May 6, 2015, 44-year-old Lieutenant (LT) Kevin McRae—a 25-year veteran of the District of Columbia (DC) Fire Department, husband, and father of three—collapsed and went into cardiac arrest immediately upon exiting a building where he had been fighting a 9th floor apartment fire for over 50 minutes. Despite near-immediate resuscitative efforts, LT McRae was pronounced dead at a nearby emergency department approximately one hour later. He became the 100th DC firefighter to die in the line-of-duty since 1856, and the 35th firefighter to die in the United States in 2015.[1] His cause of death has been listed as "overexertion."[2]

Unfortunately, LT McRae's story is not unique. Every day across the United States and worldwide, firefighters face potential acute injury and illness risks unique to their profession that must be understood by the medical professionals treating the "downed firefighter" to avoid missing a critical diagnosis. This InterAgency Board (IAB, www.interagencyboard.org) white paper outlines both the common and unique factors involved in structural and wildland firefighting that contribute to acute illness and injury risk, and provides recommendations for testing, evaluating, and resuscitating a firefighter presenting from, or immediately after, structural or wildland firefighting operations.

The term "downed firefighter" is defined as any firefighter incapable of continuing their duties due to illness, injury, weakness, altered mental status, or physical collapse during or soon after completing fire suppression and overhaul operations. All fire ground operations, especially direct fire suppression activities, are very physically taxing. Not only are the physical effort and metabolic workload during fire operations extreme, they also present multiple, unique hazards. The elevated occupational risk for firefighters is evident in the Line of Duty Death (LODD) statistics published annually by the US Fire Administration. On average, 80–100 firefighters die in the line of duty in the US each year; the leading cause of fatalities is heart attack (44%) and trauma (27%), followed by motor vehicle collisions (20–25%) and asphyxia and burns (20%). These injuries occur during training as well, with a recent rise to 6% of LODDs occurring during training.[3]

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[1] Hermann, Peter; Zapotosky, Matt; Harris, Hamill (2015, May 6). D.C. Firefighter dies after fighting an apartment fire in Shaw. *Washington Post Online*. Retrieved from www.washingtonpost.com.

[2] United States Fire Administration (2015) *Firefighter fatality report for Kevin McRae.* Retrieved from http://apps.usfa.fema.gov/firefighter-fatalities/fatalityData/detail?fatalityId=4402.

[3] United States Fire Administration (2015). *Annual Report on firefighter fatalities in the United States*. Retrieved from http://apps.usfa.fema.gov/firefighter-fatalities/fatalityData/statistics.

By improving awareness and appreciating the physiologic effects and pathologic risks encountered during structural and wildland firefighting activities, the emergency medical community can provide better care leading to improved outcomes. Firefighters face many hazards, some such as smoke inhalation and thermal injury are relatively intuitive; however, many hazards during fire ground operations are unique and therefore may be overlooked, or may not even be known to the receiving medical providers. For example, although the extreme physical exertion of firefighting is well understood within the fire and first response community, the absolute importance of the physiologic effects of that exertion may not be properly addressed or evaluated in a standard emergency department. Instead, emergency department physicians and nurses typically evaluate and treat the downed firefighter the same way they approach a civilian victim rescued from a confined space or a structure fire. There is little if any formal training in the current emergency medicine nursing and physician curriculum focusing on the effects and risks of suppressing fires. The current common medical approach includes evaluating and treating carbon monoxide toxicity and thermal injury, mostly because that is what is emphasized in medical education despite the fact that the most common causes of LODDs in firefighters are exertional cardiac arrest and sudden cardiac death.[4]

DEFINING THE PROBLEM

Recognizing the important considerations and broader differential diagnosis in caring for the downed firefighter, the IAB created this document as a recommended standardized approach to their comprehensive medical evaluation. This differential-diagnosis-based approach is intended to improve, streamline, and consistently manage these potentially complicated patients. Although the etiology of illness and cardiac arrest may be related to well-known etiologies, atypical considerations related to fire suppression activities such as dehydration, heat stress, hypoxia, and hazardous materials toxicity must routinely be included in the differential.

HAZARDS ON THE FIRE GROUND

The physiologic effects of the extreme physical exertion required for structural firefighting are compounded by equipment weight and the thermal characteristics of the required personal protective equipment (PPE). Because PPE inhibits metabolic heat loss, maximal heart rates are typically achieved immediately upon initiating fire suppression activities, and core temperatures of 104° F are common within the first 20 minutes. The resultant physiological stress, especially in firefighters who are not well-conditioned or acclimated, results in heat-related illness, profound dehydration, and cardiovascular complications including arrhythmia, myocardial infarction, and sudden cardiac death.

[4] United States Fire Administration (2015). *Annual Report on firefighter fatalities in the United States*. Retrieved from http://apps.usfa.fema.gov/firefighter-fatalities/fatalityData/statistics.

Although the inherent exposure to extreme temperatures is intuitive, other operational risks and their associated medical effects may not be. Table 1 includes the common physiologic and hazardous material risks that firefighters are exposed to during fire suppression activities. While these risks can be mitigated by using PPE, when evaluating the downed firefighter the healthcare provider must determine what PPE was used, if it was used properly, if it failed, and what condition it was in, as these factors can influence the material risks below and indicate resultant injuries.

Table 1: Physical and Hazardous material risks on the fire ground

Physical Risks
• Extreme temperatures • Uncompensable heat stress due to exertion in PPE • Extreme physical exertion and cardiovascular stress • Extreme musculoskeletal exertion • Multiple trip hazards (e.g., hoses, debris, wet surfaces, poor visibility) • Work at height • Exposed metal and sharp debris • Structural collapse • Psychological stress • Electrical hazards • Direct physical injury resulting from use of fire ground equipment
Hazardous Material Risks

• Super-heated particulates and gases include steam
• Toxic chemicals
    o Irritant gases: hydrochloric acid, sulfur dioxide, ammonia
    o Asphyxiant gases: carbon dioxide, carbon monoxide
    o Toxic gases: hydrogen sulfide, hydrogen cyanide, phosgene, carbon tetrachloride
• Hypoxic environment
• Explosive gases
• Blood and bodily fluids
• Aerosolized particulate matter

EVALUATING THE DOWNED FIREFIGHTER DURING OR AFTER FIRE SUPPRESSION ACTIVITIES

The approach to the firefighter with physical illness or altered mental status—up-to and including cardiovascular collapse, during or after fire suppression operations—begins with a comprehensive differential diagnosis. The list in Table 2 is extensive due to the wide array of physiologic and hazardous materials risks inherent in structural and wildland firefighting.

Table 2: Differential Diagnosis for the Downed Firefighter

Categories	Sub-categories
Cardiovascular	• Arrhythmia • Myocardial infarction • Sudden cardiac arrest
Electrolyte imbalance	• Hypernatremia • Hyponatremia
Exertion-related	• Exercise related collapse
General medical	• Anaphylaxis • Hypoglycemia
Heat illness	• Dehydration • Heat exhaustion • Heat stroke • Hypernatremia • Muscle tetany
Neurologic	• Cerebrovascular accident • Seizure
Psychological	• Critical incident stress
Respiratory	• Airway thermal injury • Airway chemical burns • Asthma • Acute bronchospasm • Hypoxia
Toxicologic	• Carbon Monoxide • Cyanide poisoning • Phosgene inhalation • Stimulant Use
Trauma	• Chemical burns • Closed head injury • Crush injury • Blunt torso trauma • Orthopedic injury • Radiation burns • Rhabdomyolysis • Thermal burns

RECOMMENDED STANDARD EMERGENCY DEPARTMENT APPROACH AND LABORATORY EVALUATION FOR THE DOWNED FIREFIGHTER

Based on the differential diagnosis and known physiology of firefighting activities, the IAB recommends the following diagnostic and general therapeutic approach to the downed firefighter as a minimum:

Physical Evaluation

- Rapid trauma assessment
- Concentrated airway and pulmonary assessment
- Rectal temperature

Field Diagnostic Testing

- Electrocardiogram
- Cardiac monitoring
- Finger stick glucose
- Pulse oximetry
- Pulse carbon monoxide -oximetry
- End-tidal carbon dioxide (CO_2) monitoring
- Lactate if available

Emergency Department/Trauma Center Diagnostic Testing

- Cardiac monitoring
- Pulse oximetry
- End tidal CO_2 monitoring
- Cervical spine radiographs if head injury or fall from height
- Head computed topography (CT) if altered mental status and injury mechanism suspicious for head trauma
- Focused Assessment with Sonography in Trauma bedside ultrasound if fall from height
- Chest radiograph
- Contrast-enhanced CT chest/abdomen/pelvis if indicated by traumatic mechanism
- Any indicated bone radiographs for given traumatic mechanism

Diagnostic Laboratory Testing

- Arterial blood gas
- Cell blood count
- Complete metabolic panel including, but not limited to, electrolytes, renal function tests, glucose, calcium, phosphorous, magnesium
- Creatinine phosphokinase (CPK)
- Troponin
- Lactate
- Carboxyhemoglobin

- Urinalysis
- Toxicologic screen
- Urine pregnancy test

Recommended Empiric Therapies

- 100% oxygen administration, especially if signs of smoke inhalation (humidified if inhalational injury)
- Early intubation for signs of airway burns/stridor/hoarseness
- Volume replacement with intravenous injection crystalloids
  - Consider adding sodium bicarb to alkalinize urine if extreme elevation of CPK or significant crush injury
  - Monitor urine output as marker for hydration
- Aggressive cooling if hyperthermic: Goal of rapid decrease to core body temperature of 102° to avoid core temperature overshoot below 98° as the temperature typically continues to drop after cessation of active cooling
- Standard resuscitation and management of thermal burns
- Empiric treatment for cyanide poisoning in the field or as soon as possible for altered mental status (including cardiac arrest) with known exposure to enclosed space fire or signs of smoke inhalation
- Considerations for hyperbaric oxygen therapy
- Aggressive pain management utilizing multi-modal approach to pain control
- In-patient telemetry admission for continued observation

SPECIAL CONSIDERATIONS

Irritant gases that result in severe upper airway edema, bronchospasm or pulmonary edema, often with delayed onset of effects (e.g., ammonia, acrolein, HCL, chlorine or phosgene) represent specific and unique toxicologic hazards to firefighters. Produced from the thermal combustion from chlorinated hydrocarbons[5] such as synthetic rubber, plastic pipes and house siding, inhaled gases can appear innocuous on initial presentation but can lead to significant delayed non-cardiogenic pulmonary edema. Phosgene exposure has been the documented cause of death for firefighters more than 24 hours after exposure.[6][7] All symptomatic firefighters (weak, ill, etc.) should be admitted for observation for at least 24 hours, and upon discharge should be given strict precautions to refrain from physical exertion until re-examined by a physician and to immediately return for worsening difficulties breathing.

[5] Environmental Protection Agency (2015). Report on Phosgene. Retrieved from http://www.epa.gov/ttnatw01/hlthef/phosgene.html

[6] In August 1996, several days after significant smoke exposure and despite the fact that he had been admitted for inpatient observation for 48 hours, Deputy Fire Chief Leslie Hendricks of Union Township, NJ collapsed and died at home. Cause of death at autopsy was listed as "marked tracheobronchial inflammation, alveolar hemorrhage and pulmonary edema due to smoke inhalation containing phosgene."

[7] "Just a routine fire." Retrieved from https://www.firerecruit.com/articles/915407-Just-a-routine-fire.

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