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Death in the line of duty...

NIOSH
Fire Fighter Fatality Investigation and Prevention Program

A summary of a NIOSH fire fighter fatality investigation *February, 2012*

Captain Collapses at a Structure/Grass Fire and Dies 9 Days Later – Oklahoma

Executive Summary

On July 29, 2011, a 53-year-old male career fire department captain ("the Captain") was on call when the fire department (FD) was dispatched to a grass/structure fire. At the scene, the Captain assisted in exterior fire suppression operations of the dwelling and the surrounding grass for about 13 minutes. Shortly after the fire was extinguished, the Captain suddenly collapsed. Crew members notified dispatch to request an ambulance and a medical evacuation helicopter while cardiopulmonary resuscitation (CPR) was begun. Advanced life support was provided by the ambulance service and medical helicopter personnel at the scene and during transport to the local hospital emergency department (ED). Prior to arrival at the ED, the Captain's pulse returned, but he never regained consciousness. An acute heart attack was diagnosed in the ED. The Captain was flown to a regional hospital for emergency cardiac catheterization, but the procedure was not performed because of his poor hemodynamic status. Because of the prolonged period of cardiac arrest and resuscitation efforts, the Captain suffered brain damage from lack of oxygen and had a very poor prognosis. In consultation with the Captain's family, on August 7 the decision was made to remove him from life support; he died 1 hour later.

The death certificate listed "anoxic encephalopathy due to myocardial infarction due to smoke inhalation due to fighting a grass fire" as the cause of death. No autopsy was performed. Given the Captain's probable underlying coronary artery disease, NIOSH investigators concluded that the physical stress of fire suppression activities triggered his initial cardiac event.

NIOSH investigators offer the following recommendations to address general safety and health issues. If in place before this incident, these recommendations may have prevented the Captain's death.

Provide annual medical evaluations to all fire fighters in accordance with NFPA 1582, Standard on Comprehensive Occupational Medical Program for Fire Departments.

Ensure that fire fighters are cleared for return to duty by a physician knowledgeable about the physical demands of fire fighting, the personal protective equipment used by fire fighters, and the various components of NFPA 1582.

Provide automated external defibrillators (AEDs) as part of the basic life support equipment on all fire apparatus.

The following recommendations would not have prevented the Captain's death, but they address safety and health issues that all fire departments should consider.

Phase in a mandatory comprehensive wellness and fitness program for fire fighters.

Perform an annual physical performance (physical ability) evaluation for all members.

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Use a secondary (technological) test to confirm appropriate placement of the endotracheal tube.

Request that carboxyhemoglobin levels be measured on symptomatic or unresponsive fire fighters exposed to fire smoke.

Perform an autopsy on all on-duty fire fighter fatalities.

Introduction & Methods

On July 29, 2011, a 53-year-old male career Captain suffered a heart attack and cardiac arrest shortly after fighting a structure and grass fire. After being revived, his condition deteriorated in the hospital, and he died 9 days later of anoxic encephalopathy. NIOSH contacted the affected fire department (FD) on August 9, 2011, to gather additional information, and on October 4, 2011, to initiate the investigation. On October 17, 2011, a safety and occupational health specialist from the NIOSH Fire Fighter Fatality Prevention and Investigation Program conducted an on-site investigation of the incident.

During the investigation, NIOSH personnel interviewed the following people:
- Fire Chief
- Captain's spouse

NIOSH personnel reviewed the following documents:
- FD standard operating procedures
- FD annual report for 2010
- FD incident report
- Emergency medical service (ambulance) report
- Hospital ED records
- Regional hospital records
- Death certificate
- Primary care physician records

Investigative Results

Incident. On July 29, 2011, the Captain completed his 24-hour shift at 0800 hours, but was on call for back up duty over another 24 hours. At 1232 hours, the Captain was called in for station coverage during an emergency ambulance call. He remained at the fire station until 1308 hours when he was released and returned home. At 1735 hours, the FD was dispatched for a fire involving an abandoned structure and the surrounding grass. Weather conditions included a temperature of 102 degrees Fahrenheit (°F) and relative humidity of 27%, giving a heat index of 103.9°F [NOAA 2011].

The Captain responded to the fire station and rode as the officer in Engine 6, arriving at the scene at 1758 hours along with the brush truck. Crew members found a grass fire burning around an abandoned dwelling with the dwelling burning at the front doorway and eave. The Captain, wearing full turnout gear without self-contained breathing apparatus, pulled a 100-foot section of uncharged 1¾-inch preconnected hoseline. After the hoseline was charged, the Captain attacked the fire at the eave and the doorway. After about 10 minutes of exterior suppression, the Captain and other crew members began overhaul and extinguishing hot spots.

During overhaul, the Captain and crew members took a break to cool off and rehydrate. They removed their turnout coats and sat down while drinking water and sports drinks for about 10 minutes. As the fire fighters donned their protective clothing to continue overhaul, the Captain collapsed (1823 hours).

Assessment by crew members found the Captain unresponsive, pulseless, and not breathing. An ambulance and a medical helicopter were requested (1825 hours) as CPR was begun. The ambulance arrived 15 minutes later (1840 hours) with CPR

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Investigative Results (cont.)

in progress. An automated external defibrillator (AED) was placed onto the Captain's chest, and a shock was advised and delivered. The shock did not change the Captain's heart rhythm, and CPR continued as the Captain was placed into the ambulance. Inside the ambulance intubation was attempted twice without success.

The medical helicopter arrived at 1849 hours, and the flight crew successfully intubated the Captain, but no secondary confirmation test to verify tube placement was performed. Two intravenous lines were placed, and advanced life support medications were administered. The flight crew noted a pulse; CPR was stopped while assisted ventilations continued. At this time the Captain had been without a pulse for about 30 minutes. The pulse was barely palpable, and CPR was resumed. The ambulance departed the scene en route to the hospital ED at 1852 hours. While en route, at 1900 hours, the Captain's pulse returned at a rate of 100 beats per minute, and CPR was stopped; his blood pressure was measured at 60 millimeters of mercury (mmHg) systolic by palpation. The ambulance arrived at the local hospital ED at 1904 hours.

Upon arrival in the ED, the Captain's blood pressure was in the 80–90 mmHg systolic range with a pulse ranging from 130 to 140 beats per minute. His body temperature was 98.4°F. Blood testing revealed normal levels of cardiac enzymes, while an electrocardiogram (EKG) revealed atrial fibrillation, right bundle branch block, and borderline ST-segment elevation in V2 to V4 suggesting an acute heart attack (myocardial infarction). The Captain's atrial fibrillation was successfully treated, but he needed vasopressors (dopamine drip) to maintain his blood pressure. On dopamine his blood pressure was 137/72 mmHg with a sinus rhythm of 115 beats per minute. Despite the relative stabilization of his blood pressure and heart rhythm, the Captain remained unresponsive. Emergency medical treatment continued in the local hospital ED until 2050 hours when the Captain was flown to a regional hospital for possible emergent cardiac catheterization and angioplasty.

At the regional hospital, another EKG revealed similar findings (sinus rhythm, right bundle branch block, and borderline ST elevation in the anterolateral leads suggesting an acute heart attack). His blood cardiac enzymes were now (about 4 hours post collapse) elevated (troponin level of 35.326 nanograms per milliliter [ng/mL]; normal level is < 0.06 ng/mL) confirming the occurrence of an acute heart attack. An echocardiogram revealed a hyperdynamic systolic function (ejection fraction of 75%) due to the IV vasopressors, grade I diastolic dysfunction, mildly thickened aortic valve leaflets, and a thickened left ventricle (3.0 centimeters [cm]) (normal by echocardiographic measurement is 0.6–1.0 cm) [Connolly and Oh 2012]. No regional wall motion abnormalities were noted.

Throughout this incident the Captain was unresponsive. A computed tomography scan of his head and an electroencephalogram showed findings consistent with brain damage due to lack of oxygen (anoxia) during the prolonged cardiac arrest and resuscitation efforts. Given his extremely poor prognosis and unstable cardiac status, no emergency cardiac catheterization was performed. Over the next 9 days, the Captain's condition deteriorated and on August 7, after consulting with the family, the decision was made to remove the Captain from life support. Approximately 1 hour after removing the life support, the attending physician pronounced the Captain dead at 1540 hours.

Investigative Results (cont.)

Medical Findings. The death certificate, completed by the medical examiner, listed "anoxic encephalopathy due to myocardial infarction due to smoke inhalation due to fighting a grass fire" as the cause of death. No autopsy was performed.

The Captain was 70 inches tall and weighed 238 pounds, giving him a body mass index of 34.1 kilograms per meters squared. A body mass index > 30.0 kilograms per meter squared is considered obese [CDC 2011]. The Captain's other risk factors for coronary artery disease (CAD) included type II diabetes mellitus (diagnosed in 2002), hyperlipidemia (high blood cholesterol and triglycerides diagnosed in 2004), and hypertension (high blood pressure diagnosed in 2007). He was prescribed a diabetic medication in 2004, a cholesterol-lowering medication in 2008, and a blood pressure-lowering medication in 2009. The Captain's cholesterol and hypertension were successfully treated, but his diabetes was poorly controlled (hemoglobin A1C [HA1C] level in the 9.2–10.9 range) until 2009 when he achieved better control (HA1C levels 6.9–7.7).

During his preplacement medical evaluation on November 2, 1990, the Captain exercised 9 minutes on the Bruce protocol, achieving 10.1 metabolic equivalents during a treadmill stress test. The Captain reported no symptoms and had a normal blood pressure response to exercise. The EKG showed no arrhythmias or changes suggestive of ischemia. The test was stopped when the Captain reached Stage 4 of the Bruce protocol. No subsequent stress tests were performed by the FD or his primary care physician. The Captain never complained of cardiac symptoms.

Description of the Fire Department

At the time of the NIOSH investigation, the FD consisted of one fire station with 10 career and 12 volunteer uniformed personnel and served 5,100 residents in a geographic area of 100 square miles. In 2010, the FD responded to 699 incidents: 41 fire calls, 13 hazardous materials calls, 13 automatic alarm calls, 10 mutual aid calls, 603 medical calls, and 19 other calls.

Membership and Training. The FD requires new fire fighter applicants to be 21 years of age, have a valid state driver's license, be trained to the Fire Fighter 1 and emergency medical technician levels, pass an interview, be recommended to the city manager, and pass a physical agility test, a preplacement medical evaluation, a drug screen, and a background check. After receiving a job offer, the new hire is placed on probation for 1 year and receives training to the Fire Fighter 2 level along with other fire fighter training. Career fire fighters work a 24-hour shift, followed by 24 hours on call, then 24 hours off duty. The Captain was certified as a Fire Officer, Fire Fighter 2, Emergency Medical Technician, Fire Instructor, Fire Inspector, Wildland Fire Fighter, and in Hazardous Materials Operations. He had 25 years of fire fighting experience.

Preplacement Medical Evaluations. The State of Oklahoma requires preplacement medical evaluations for all applicants. Components of the medical evaluation include the following:

- Complete medical history
- Physical examination (including vital signs)
- Complete blood count
- Urinalysis
- Urine drug screen
- Spirometry

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Description of the FD (cont.)

- Resting EKG
- Exercise stress test
- Chest x-ray (baseline)
- Hearing (audiometric) test
- Vision screen

The evaluations are performed by a state pension board-contracted physician. Once this evaluation is complete, the contract physician makes a determination regarding medical clearance for fire fighting duties and forwards this decision to the FD. The Captain completed his medical evaluation on November 2, 1990, and was cleared for fire fighting duties.

Periodic Medical Evaluations. Neither the state nor the FD requires periodic (annual) medical evaluations. However, medical clearance to wear a respirator and spirometry are required annually. These are performed by a contractor who also provides the annual self-contained breathing apparatus facepiece fit test. Members injured on duty must be evaluated by the member's primary care physician who forwards his or her determination for return to duty to the FD. Members who are ill and are off for two or more shifts must be cleared for return to work by their primary care physician.

Health and Wellness Programs. The FD does not have a wellness/fitness program, but exercise equipment is available in the fire station. No annual physical ability test is required. The Captain did not participate in an exercise program.

Discussion

Atherosclerotic Coronary Artery Disease. In the United States, atherosclerotic CAD is the most common risk factor for cardiac arrest and sudden cardiac death [Meyerburg and Castellanos 2008]. Risk factors for its development include age older than 45, male gender, family history of CAD, smoking, high blood pressure, high blood cholesterol, obesity/physical inactivity, and diabetes [AHA 2011a; NHLBI 2011]. The Captain had six CAD risk factors (age older than 45, male gender, high blood pressure, high blood cholesterol, obesity, and diabetes mellitus).

The narrowing of the coronary arteries by atherosclerotic plaques occurs over many years, typically decades [Libby 2008]. However, the growth of these plaques probably occurs in a nonlinear, often abrupt fashion [Shah 1997]. Heart attacks typically occur with the sudden development of complete blockage (occlusion) in one or more coronary arteries that have not developed a collateral blood supply [Fuster et al. 1992]. This sudden blockage is primarily due to blood clots (thromboses) forming on top of atherosclerotic plaques. Establishing a recent (acute) heart attack requires any of the following: characteristic EKG changes, elevated cardiac enzymes, or coronary artery thrombus. In this case, the Captain's cardiac enzymes were elevated, confirming an acute heart attack (myocardial infarction).

Epidemiologic studies have found that heavy physical exertion sometimes immediately precedes and triggers the onset of acute heart attacks and sudden cardiac death [Albert et al. 2000]. Heart attacks in fire fighters have been associated with alarm response, fire suppression, and heavy exertion during training (including physical fitness training) [Kales et al. 2003; Kales et al. 2007; NIOSH 2007]. The Captain had responded to the alarm and performed fire fighting activities. These activities expended about 9

Discussion (cont.)

METs, which is considered moderate physical activity [Gledhill and Jamnik 1992; Ainsworth et al. 2011].

Occupational Medical Standards for Structural Fire Fighters. To reduce the risk of sudden cardiac arrest or other incapacitating medical conditions among fire fighters, the NFPA developed NFPA 1582, Standard on Comprehensive Occupational Medical Program for Fire Departments [NFPA 2007a]. This voluntary industry standard provides the components of a preplacement and annual medical evaluation and medical fitness for duty criteria. The Captain had two conditions relevant to medical clearance: diabetes mellitus (known condition) and coronary heart disease (CHD) (unknown condition).

Diabetes Mellitus. NFPA 1582 provides guidance for fire department physicians to follow when treating diabetic fire fighters. The standard states that fire fighters with diabetes mellitus that is controlled by diet, exercise, and/or oral hypoglycemic agents should be restricted from duty unless the member meets all of the following criteria:

- If on oral hypoglycemic agents, has had no episodes of severe hypoglycemia (defined as requiring assistance of another in the preceding year)
- Has achieved a stable blood glucose as evidenced by HA1C level less than 8 during the prior 3-month period
- Has a dilated retinal exam by a qualified ophthalmologist or optometrist that shows no higher grade of diabetic retinopathy than microaneurysms
- Has normal renal function on the basis of a calculated creatinine clearance greater than 60 milliliters per minute and absence of proteinuria
- Has no autonomic or peripheral neuropathy
- Has normal cardiac function without evidence of myocardial ischemia on cardiac stress testing (to at least 12 METs) by EKG and cardiac imaging [NFPA 2007a].

The Captain had type II diabetes and used oral agents (not insulin). Although the Captain reported no hypoglycemic episodes, he did not fulfill any of the other remaining criteria for unrestricted duty, primarily because of lack of testing.

Coronary Heart Disease and Exercise Stress Tests. The Captain had multiple risk factors for CHD and, despite being asymptomatic, should have had an exercise stress test to screen for CHD. Recommendations for conducting exercise stress tests on asymptomatic individuals without known heart disease are varied. The following paragraphs summarize the positions of widely recognized organizations on this topic.

National Fire Protection Association (NFPA) 1582, a voluntary industry standard, recommends an exercise stress test be performed "as clinically indicated by history or symptoms" and refers the reader to Appendix A [NFPA 2007a]. Items in Appendix A are not standard requirements, but are provided for "informational purposes only." Appendix A recommends using submaximal (85% of predicted heart rate) stress tests as a screening tool to evaluate a fire fighter's aerobic capacity. Maximal (e.g., symptom-limiting) stress tests with imaging should be used for fire fighters with the following conditions:

- abnormal screening submaximal tests
- cardiac symptoms
- known coronary artery disease
- two or more risk factors for CAD (in men older than 45 and women older than 55)

Risk factors are defined as hypercholesterolemia (total cholesterol greater than 240 milligrams per deci-

Discussion (cont.)

liter), hypertension (diastolic blood pressure greater than 90 mm of mercury), smoking, diabetes mellitus, or family history of premature CAD (heart attack or sudden cardiac death in a first-degree relative less than 60 years old).

The American College of Cardiology/American Heart Association (ACC/AHA) has also published exercise testing guidelines [Gibbons et al. 2002]. The ACC/AHA guideline states that the evidence to conduct stress tests in asymptomatic individuals with diabetes mellitus is "Class IIa," which is defined as "conflicting evidence and/or a divergence of opinion about the usefulness/efficacy but the weight of the evidence/opinion is in favor." The ACC/AHA guideline states the evidence is "less well established" (Class IIb) for the following groups:

- persons with multiple risk factors (defined similarly to those listed by the NFPA)
- asymptomatic men older than 45 years and women older than 55 years:
  - who are sedentary and plan to start vigorous exercise
  - who are involved in occupations in which impairment might jeopardize public safety (e.g., fire fighters)
  - who are at high risk for coronary artery disease due to other diseases (e.g., peripheral vascular disease and chronic renal failure)

The U.S. Department of Transportation provides guidance for those seeking medical certification for a commercial driver's license. An expert medical panel recommended exercise tolerance tests (stress tests) for asymptomatic high risk drivers [Blumenthal 2007]. The panel defines high risk drivers as those with any of the following:

- diabetes mellitus
- peripheral vascular disease
- age 45 and above with multiple risk factors for coronary heart disease
- Framingham risk score predicting a 20% coronary heart disease event risk over the next 10 years

The U.S. Preventive Services Task Force (USPSTF) does not recommend stress tests for asymptomatic individuals at low risk for coronary heart disease events. For individuals at increased risk for coronary heart disease events, the USPSTF found "insufficient evidence to recommend for or against routine screening with EKG, exercise tolerance test, or electron beam computerized tomography scanning…." Rather, the USPSTF recommends the diagnosis and treatment of modifiable risk factors (hypertension, high cholesterol, smoking, and diabetes) [USPSTF 2004]. The USPSTF does note that "For people in certain occupations, such as pilots, and heavy equipment operators (for whom sudden incapacitation or sudden death may endanger the safety of others), consideration other than the health benefit to the individual patient may influence the decision to screen for coronary heart disease."

Given the Captain's age and CAD risk profile, the NFPA, the ACC/AHA, and the DOT would have recommended a symptom-limiting exercise stress test.

Left Ventricular Hypertrophy. In the hospital, the Captain was found to have left ventricular hypertrophy (LVH) by echocardiogram. LVH increases the risk for sudden cardiac death [Levy et al. 1990]. Hypertrophy of the heart's left ventricle is a relatively common finding among individuals with long-standing high blood pressure (hypertension), a heart valve problem, or chronic cardiac ischemia (reduced blood supply to the heart muscle) [Siegel 1997]. The Captain had a history of hypertension, and this was most likely responsible for his LVH.

Recommendations

NIOSH investigators offer the following recommendations to address general safety and health issues. If in place before this incident, these recommendations may have prevented the Captain's death.

Recommendation #1: Provide annual medical evaluations to all fire fighters in accordance with NFPA 1582, Standard on Comprehensive Occupational Medical Program for Fire Departments.

Guidance regarding the content and frequency of these medical evaluations can be found in NFPA 1582 and in the International Association of Fire Fighters (IAFF)/International Association of Fire Chiefs (IAFC) Fire Service Joint Labor Management Wellness/Fitness Initiative [NFPA 2007a; IAFF, IAFC 2008]. These evaluations are performed to determine fire fighters' medical ability to perform duties without presenting a significant risk to the safety and health of themselves or others. To ensure improved health and safety of candidates and members, and to ensure continuity of medical evaluations, it is recommended the FD comply with this recommendation, particularly the section devoted to stress tests to screen for coronary heart disease. However, the FD is not legally required to follow the NFPA standard or the IAFF/IAFC initiative. Applying this recommendation involves economic repercussions and may be particularly difficult for smaller fire departments to implement.

To overcome the financial obstacle of medical evaluations, the FD could urge current members to get annual medical clearances from their private physicians. Another option is having the annual medical evaluations completed by paramedics and emergency medical technicians from the local ambulance service (vital signs, height, weight, visual acuity, and EKG). This information could then be provided to a community physician (perhaps volunteering his or her time), who could review the data and provide medical clearance (or further evaluation, if needed). The more extensive portions of the medical evaluations could be performed by a private physician at the fire fighter's expense (personal or through insurance), provided by a physician volunteer, or paid for by the FD, city, or state. Sharing the financial responsibility for these evaluations between fire fighters, the FD, the city, the state, and physician volunteers may reduce the negative financial impact on recruiting and retaining needed fire fighters.

Recommendation #2: Ensure that fire fighters are cleared for return to duty by a physician knowledgeable about the physical demands of fire fighting, the personal protective equipment used by fire fighters, and the various components of NFPA 1582.

Guidance regarding medical evaluations and examinations for structural fire fighters can be found in NFPA 1582 and in the IAFF/IAFC Fire Service Joint Labor Management Wellness/Fitness Initiative [NFPA 2007a; IAFF, IAFC 2008]. According to these guidelines, the FD should have an officially designated physician who is responsible for guiding, directing, and advising the members with regard to their health, fitness, and suitability for duty. The physician should review job descriptions and essential job tasks required for all FD positions and ranks to understand the physiological and psychological demands of fire fighters and the environmental conditions under which they must perform, as well as the personal protective equipment they must wear during various types of emergency operations. The FD currently uti-

Recommendations (cont.)

lizes the member's personal physician to clear fire fighters injured on duty or who miss two or more shifts due to illness. The extent of these physicians' knowledge of the fire fighting duties of their patients is unknown.

Recommendation #3: Provide automated external defibrillators (AEDs) as part of the basic life support equipment on all fire apparatus.

Preservation of human life is the primary responsibility of the fire department during fires and other emergencies. Fire departments should be prepared to perform rescue work and provide emergency care for those injured including persons experiencing cardiac arrest [NFPA 2010]. Most of the sudden cardiac deaths in the United States result from ventricular fibrillation. The chain of survival from cardiac arrest includes: (1) immediate recognition of cardiac arrest and activation of the emergency response system, (2) early CPR with an emphasis on chest compressions, (3) rapid defibrillation, (4) effective advanced life support, and (5) integrated post-cardiac arrest care [AHA 2011b]. Rapid defibrillation using AEDs has increased the cardiac arrest survival rate from 5% (CPR performed only) to 26% [AHA 2000]. When defibrillation is provided within 3 minutes, the survival rate is as high as 74% [AHA 2004]. To provide emergency medical care, adequate supplies and equipment should be available to treat bleeding, fractures, cardiac arrest, etc. Placing AEDs on fire apparatus, in addition to carrying defibrillators on ambulances, would allow the FD to provide a greater level of emergency medical care to the public. The FD has medical first responder responsibilities and fire fighters may find themselves in the position of having to provide CPR. The timely use of an AED, even by minimally trained first responders, can increase the likelihood of survival following cardiac arrest [Marenco et al. 2001; Koster 2002].

The following recommendations would not have prevented the Captain's death, but they address safety and health issues that all fire departments should consider.

Recommendation #4: Phase in a mandatory comprehensive wellness and fitness program for fire fighters.

Guidance for fire department wellness/fitness programs to reduce risk factors for cardiovascular disease and improve cardiovascular capacity is found in NFPA 1583, Standard on Health-Related Fitness Programs for Fire Fighters, the IAFF/IAFC Fire Service Joint Labor Management Wellness/Fitness Initiative, the National Volunteer Fire Council (NVFC) Health and Wellness Guide, and in Firefighter Fitness: A Health and Wellness Guide [USFA 2004; IAFF, IAFC 2008; NFPA 2008; Schneider 2010]. Worksite health promotion programs have been shown to be cost effective by increasing productivity, reducing absenteeism, and reducing the number of work-related injuries and lost work days [Stein et al. 2000; Aldana 2001]. Fire service health promotion programs have been shown to reduce CAD risk factors and improve fitness levels, with mandatory programs showing the most benefit [Dempsey et al. 2002; Womack et al. 2005; Blevins et al. 2006]. A study conducted by the Oregon Health and Science University reported a savings of more than $1 million for each of four large fire departments implementing the IAFF/IAFC wellness/fitness program compared to four large fire departments not implementing a program. These savings were primarily due to

Recommendations (cont.)

a reduction of occupational injury/illness claims with additional savings expected from reduced future nonoccupational healthcare costs [Kuehl 2007]. The FD currently has a voluntary wellness/fitness program for career and volunteer personnel. Given the FD's structure, the NVFC program would be very helpful [USFA 2004]. NIOSH recommends a formal, mandatory wellness/fitness program to ensure all members receive the benefits of a health promotion program. During exercise time, employees should be taken out of service to ensure uninterrupted participation.

Recommendation #5: Perform an annual physical performance (physical ability) evaluation for all members.

NFPA 1500, Standard on Fire Department Occupational Safety and Health Program, requires the FD to develop physical performance requirements for candidates and members who engage in emergency operations [NFPA 2007b]. Members who engage in emergency operations must be annually qualified (physical ability test) as meeting these physical performance standards for structural fire fighters [NFPA 2007b]. This could be incorporated into the annual task-level training program.

Recommendation #6: Use a secondary (technological) test to confirm appropriate placement of the endotracheal tube.

To reduce the risk of improper intubation, the AHA and the International Liaison Committee on Resuscitation published recommendations in the "Guidelines 2000 for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care" [AHA 2010]. These guidelines recommend confirming tube placement by primary and secondary methods. Primary confirmation is the five-point auscultation: left and right anterior chest, left and right midaxillary, and over the stomach. Secondary confirmation requires a technology test, either an end-tidal carbon dioxide detector or an esophageal detector device. In this incident, tube placement was verified by lack of audible abdominal sounds; however, secondary confirmation was not performed until 0612 hours in the ED. This issue did not contribute to the Captain's death. We make this recommendation to ensure that future advanced life support resuscitation efforts follow AHA guidelines.

Recommendation #7: Request that carboxyhemoglobin levels be measured on symptomatic or unresponsive fire fighters exposed to fire smoke.

The hospitals involved in the Captain's care did not measure a carboxyhemoglobin (COHb) level. COHb is a blood test used to estimate an individual's exposure to carbon monoxide. Fire smoke contains varying amounts of carbon monoxide and can cause carbon monoxide poisoning, which, in severe cases, can cause sudden death. The Captain was unlikely to have carbon monoxide poisoning from his relatively brief (10-minute) exposure to light fire smoke. Furthermore, even if his COHb level was elevated, this would not have affected his treatment or outcome because he was already receiving 100% oxygen therapy via respirator. Nonetheless, we recommend measuring COHb levels in all fire-related deaths to rule out carbon monoxide poisoning.

Recommendation #8: Perform an autopsy on all on-duty fire fighter fatalities.

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Recommendations (cont.)

In 2008, the USFA published the Firefighter Autopsy Protocol [USFA 2008]. With this publication, the USFA hoped to provide "a more thorough documentation of the causes of firefighter deaths for three purposes:

1. to advance the analysis of the causes of firefighter deaths to aid in the development of improved firefighter health and safety equipment, procedures, and standards;

2. to help determine eligibility for death benefits under the Federal government's Public Safety Officer Benefits Program, as well as state and local programs; and

3. to address an increasing interest in the study of deaths that could be related to occupational illnesses among firefighters, both active and retired."

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Investigator Information

This incident was investigated by the NIOSH Fire Fighter Fatality Investigation and Prevention Program, Cardiovascular Disease Component in Cincinnati, Ohio. Mr. Tommy Baldwin (MS) led the investigation and co-authored the report. Mr. Baldwin is a Safety and Occupational Health Specialist, a National Association of Fire Investigators (NAFI) Certified Fire and Explosion Investigator, an International Fire Service Accreditation Congress (IFSAC) Certified Fire Officer I, and a former Fire Chief and Emergency Medical Technician. Dr. Thomas Hales (MD, MPH) provided medical consultation and co-authored the report. Dr. Hales is a member of the NFPA Technical Committee on Occupational Safety and Heath, and Vice-Chair of the Public Safety Medicine Section of the American College of Occupational and Environmental Medicine (ACOEM).