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NIOSH
Fire Fighter Fatality Investigation and Prevention Program

Death in the line of duty...

A summary of a NIOSH fire fighter fatality investigation *October 2008*

Fire Fighter-Emergency Medical Technician Suffers Sudden Cardiac Death After Multiple Emergency Responses – Massachusetts

SUMMARY

On September 14, 2007, a 38-year-old male career Fire Fighter-Emergency Medical Technician (FF-EMT) responded to six calls during his shift, including a fire in an apartment building. At the apartment fire, the FF-EMT performed forcible entry at multiple locations throughout the building while wearing full turnout gear and self-contained breathing apparatus (SCBA). He was still sweating profusely after returning to the fire station. After resting for about 60 minutes, his engine company was dispatched to back-to-back calls involving an automobile accident and downed power lines. About 5½ hours later, the FF-EMT went to the engine bay to restore equipment in the medical bag. A short while later, the Lieutenant (LT) found the FF-EMT lying next to Engine 6. Assessment of the FF-EMT revealed he was unresponsive, not breathing, and pulseless. Crew members and an ambulance were alerted as the LT obtained the automated external defibrillator (AED)and oxygen bag from the Engine and began cardiopulmonary resuscitation (CPR). One shock was administered before the ambulance and paramedics arrived. Despite CPR and advanced life support administered on-scene, during transport, and in the hospital's Emergency Department, the FF-EMT died. The death certificate (completed by the City Clerk) and the autopsy (completed by the State Chief Medical Examiner) listed "atherosclerotic cardiovascular disease" as the cause of death. The NIOSH investigator concludes the FF-EMT's underlying atherosclerotic coronary artery disease (CAD), coupled with his alarm responses and exertional activities at six calls (including a structure fire) triggered his sudden cardiac death.

The NIOSH investigator offers the following recommendations to address general safety and health issues. It is possible these recommendations could have prevented the FF-EMT's sudden cardiac death at this time.

- ***Conduct annual medical evaluations.***
- ***Phase-in a comprehensive wellness and fitness program for fire fighters to reduce risk factors for cardiovascular disease and improve cardiovascular capacity.***
- ***Perform an annual physical performance (physical ability) evaluation to ensure fire***
- ***fighters are physically capable of performing the essential job tasks of structural firefighting.***

- ***Provide fire fighters with medical clearance to wear self-contained breathing apparatus (SCBA)***
- ***as part of the Fire Department's medical evaluation program.***
- ***Use a secondary (technological) test to confirm appropriate placement of the endotracheal tube.***
- ***Follow NFPA 1582 guidelines for when and how to restrict fire fighters with specific medical conditions.***

INTRODUCTION & METHODS

On September 14, 2007, a 38-year-old male FF-EMT lost consciousness after responding to six calls, including a fire in a multi-story apartment building at which he performed forcible entry numerous times. Despite CPR and advanced life support administered by crew members, the ambulance crew, and in the Emergency Department, the FF-EMT died. NIOSH was notified of this fatality on September 17, 2007 by the United States Fire Administration. NIOSH contacted the affected Fire Department to gather additional information on September 19, 2007, and on July 8, 2008 to initiate the investigation. On July 21, 2008, a Safety and Occupational Health Specialist from the NIOSH Fire Fighter Fatality Investigation Team traveled to Massachusetts to conduct an on-site investigation of the incident.

During the investigation, NIOSH personnel interviewed the following people:

- Fire Chief
- International Association of Fire Fighters (IAFF) Local President
- Crew members of the FF-EMT
- FF-EMT's spouse

NIOSH personnel reviewed the following documents:

- Fire Department policies and operating guidelines
- Fire Department training records
- Fire Department annual report for 2007
- Fire Department incident reports
- Emergency medical service (ambulance) incident report
- Fire Department physical examination protocols
- Emergency Department record
- Death certificate
- Autopsy record
- Primary care provider medical records

RESULTS OF INVESTIGATION

Incident. On September 14, 2007, the FF-EMT reported for duty at approximately 0730 hours to begin his 24-hour shift. He was normally assigned to Engine 4, but was detailed to Engine 6 this shift. At 0801 hours, Engine 6 was dispatched to a medical assist call. On-scene, the FF-EMT assisted the ambulance EMTs with

loading the patient for transport. After clearing the scene at 0817 hours and returning to the station, Engine 6 was dispatched (0840 hours) to a smoke detector activation call. The FF-EMT walked the building with his Captain to discover a faulty smoke detector on the first floor. After the alarm system was reset, Engine 6 cleared the scene at 0850 hours. Eight minutes later, Engine 6 was dispatched to the same location for a second smoke detector activation call. The FF-EMT walked the building again and found the same detector that had activated before. The detector zone was disabled and the alarm system was reset. At both smoke detector calls, the FF-EMT wore full turnout gear and SCBA. Engine 6 cleared the scene at 0912 hours and returned to quarters.

At 1334 hours, Engine 6, two additional engines, and a ladder truck were dispatched to a fire in a vacant six-story apartment building. Upon arrival, the FF-EMT, wearing full turnout gear and SCBA (not on air), removed plywood from the front door allowing suppression crews to enter the structure. Once inside, a burning odor was detected. The FF-EMT used forced entry to several apartment units inside the building, and ascended and descended several flights of stairs while attempting to locate the source of the odor. His Captain noticed him sweating profusely, but thought it was consistent with the high temperature inside the building. The source of the fire was eventually determined to be a newspaper burning in the basement. The small fire was extinguished and companies returned to quarters at 1359 hours. Upon returning to the fire station, the FF-EMT removed his turnout gear and rested in a chair in the station's bay. According to crew members, he looked hot and exhausted, but stated he was okay.

From 1522 to 1537 hours, Engine 6 responded to calls for an automobile accident and downed wires. Upon return to the fire station, the FF-EMT complained of shortness of breath and requested that his condition be entered into the station's log book, but he wanted to remain on-duty. The crew ate dinner from approximately 1830 until 1915 hours. After dinner, they cleaned the kitchen until around 1940 hours.

The FF-EMT then proceeded to Engine 6 and inspected the medical bag and related equipment for the next 15 minutes. The LT asked the FF-EMT and a crew member to restock the medical bag, and the LT went into the office to complete paperwork (approximately 2009 hours). A few minutes later, the LT found the FF-EMT lying unconscious on the bay floor next to Engine 6. The FF-EMT was unresponsive with no pulse or respirations. The LT pulled the AED and the oxygen bag from Engine 6 and yelled for help. CPR was begun as crew members arrived to assist. Dispatch was notified and an ambulance and paramedics were dispatched (2019 hours).

The AED was applied to the FF-EMT's chest and one shock was advised and administered with no change in the FF-EMT's clinical status. No additional shocks were advised. The ambulance and paramedics arrived at 2021 hours and found the FF-EMT with CPR in progress. A cardiac monitor revealed pulseless electrical activity. An intubation tube was

placed and bilateral breath sounds were noted. Two intravenous lines were placed and cardiac resuscitation medications were administered. The FF-EMT was defibrillated two additional times, and the ambulance departed the scene en route to the hospital's Emergency Department at 2034 hours. During transport, two additional shocks were administered with no change in the FF-EMT's condition.

The ambulance arrived at the hospital at 2037 hours. Inside the Emergency Department, CPR and advanced life support measures (including three additional defibrillation attempts and cardiac pacing) continued while the FF-EMT was unresponsive with no heart beat and no spontaneous breathing. Resuscitation efforts continued until 2117 hours (about 62 minutes since the FF-EMT collapsed), when he was pronounced dead by the attending physician.

Medical Findings. The death certificate (completed by the City Clerk) and the autopsy (completed by the State Chief Medical Examiner on September 16, 2007), listed "atherosclerotic cardiovascular disease" as the cause of death. The autopsy showed an enlarged heart with severe coronary artery disease, biventricular hypertrophy, and fibrosis consistent with an old heart attack. (See Appendix A for a more complete listing of autopsy findings).

The FF-EMT was 72 inches tall and weighed 235 pounds, giving him a body mass index (BMI) of 31.9. The FF-EMT lifted weights regularly and was very muscular. Medical records show he had a history of hyperlipidemia (elevated blood triglyceride level since 1994, elevated blood cholesterol since 2001, decreased high density lipoprotein blood level since 2004, and an elevated low density lipoprotein blood level since 2004). He was diagnosed with diabetes mellitus in 2004. He was treated with a cholesterol-lowering medication and insulin. In 2005, the FF-EMT was injured when he dropped a 300-pound barbell onto his chest. He suffered multiple rib fractures and a pneumothorax. An electrocardiogram (EKG) revealed a right bundle branch block, which resolved prior to his discharge from the hospital. An echocardiogram conducted at that time revealed a mildly enlarged left atrium with a normal left ventricular ejection fraction, and no left ventricular hypertrophy. The FF-EMT had a malignant melanoma (skin cancer) diagnosed in 1996, that was successfully removed.

According to crew members and family, the FF-EMT had no complaints of chest pains, unusual shortness of breath on exertion, or any other heart-related symptoms during the days, weeks, or months prior to his death. However, two shifts prior to his death, he complained of a "deep chest muscle pull."

DESCRIPTION OF THE FIRE DEPARTMENT

At the time of the NIOSH investigation, the Fire Department consisted of 201 uniformed career personnel and served a population of 105,000 residents in a geographic area of 14.5 square miles. The Fire Department has 8 fire stations. Fire fighters work the following

schedule: 24 hours on-duty, 72 hours off-duty, from 0800 hours to 0800 hours.

In 2007, the Fire Department responded to 12,129 calls: 5,272 rescue/emergency medical calls, 412 structure fires, 51 vehicle fires, 186 other fires, 2,413 false calls, 456 good intent calls, 2,387 service calls, 622 hazardous condition calls, 12 overpressure rupture calls, 7 weather-related calls, and 311 other calls.

Employment and Training. The Fire Department requires all new fire fighter applicants to be 18 years of age, pass a state civil service test, and pass a physical ability test. The candidate is ranked and placed on an eligibility list for 2 years. When a vacancy occurs, the candidate must pass a background check, an oral interview, and a pre-placement medical evaluation (described below). The candidate is then placed on the Fire Department reserve list. Based on rank, the candidate is hired to fill a vacancy. If the candidate is on the reserve list longer than a year, the candidate must pass another pre-placement medical evaluation and a physical ability test. Once hired, the fire fighter must pass the 12-week fire fighter training course at the State Fire Academy to become certified as a Fire Fighter I and II. The FF-EMT was certified as a Fire Fighter II, EMT, HazMat Technician, and had 5 years of firefighting experience.

Pre-placement Medical Evaluation. The State requires a pre-placement medical evaluation for all new municipal fire fighter candidates, regardless of age. Components of this evaluation include the following:

- Complete medical history
- Physical examination (including vital signs)
- Complete blood count with lipid panel
- Pulmonary function test
- Audiogram
- Vision screen
- Urinalysis
- Urine drug screen
- Resting EKG
- Chest x-ray (baseline)
- Purified protein derivative tuberculosis test
- Hepatitis B vaccinations
- Tetanus vaccines or boosters (if needed)

These evaluations are performed by a State-certified physician whose findings are reviewed by a State standards and wellness community physician, who makes a determination regarding medical clearance for firefighting duties.

Periodic Medical Evaluations. Periodic medical evaluations are offered by the Fire Department only for fire fighters who are retiring/leaving the Department. These evaluations would be performed by the fire fighter's primary care physician. The local hospital offers voluntary periodic health screenings which include an EKG, blood work, and cancer screening. The results of these screenings are shared only with the fire fighter.

Annual SCBA medical clearance is not required. If a fire fighter is injured at work, he/she must be evaluated by their primary care physician. The results are reviewed by the City physician, who makes the final determination regarding "return to work." There is no requirement for "return to work" clearance for non-occupational injuries or illnesses. As a result, the FF-EMT was not placed on restricted duty when diagnosed with insulin-dependent diabetes mellitus in 2004, and prescribed narcotics for his rib injury in 2005 [NFPA 2007a].

Health and Wellness Programs. Exercise (strength and aerobic) equipment is located in the fire stations. The Fire Department maintains a voluntary on-duty wellness/fitness program. An annual physical ability test is not required.

DISCUSSION

Coronary Artery Disease (CAD) and the Pathophysiology of Heart Attacks. In the United States, CAD (atherosclerosis) is the most common risk factor for cardiac arrest and sudden cardiac death [Meyerburg and Castellanos 2008]. Risk factors for its development include age over 45, male gender, family history of CAD, diabetes, high blood pressure, high blood cholesterol, smoking, and obesity/physical inactivity [AHA 2008a]. The FF-EMT had four of these risk factors (male gender, family history of CAD, diabetes, and high blood cholesterol), and had CAD on autopsy and evidence of an old heart attack (fibrosis) on autopsy. A BMI >30.0 kilograms per meters squared (kg/m2) is considered obese [CDC 2008]. A skinfold test, however, may be a more accurate method of determining percent body fat than BMI [Jackson and Pollock 2004; Nooyens et al. 2007]. The FF-EMT had a BMI of 31.9, but, again, he lifted weights and was very muscular.

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. On autopsy, the FF-EMT did not have a thrombus in his coronary arteries, but he did have 95% occlusion of the right coronary artery, and 90% occlusion of the left circumflex coronary artery with an acute hemorrhage into one of its atheromatous plaques.

Establishing the occurrence of a recent (acute) heart attack requires any of the following: characteristic EKG changes, elevated cardiac enzymes, or coronary artery thrombus. In the FF-EMT's case, he never regained a heart rhythm, the EKG did not reveal characteristic changes, cardiac enzyme testing was not performed (but the enzymes do not become positive for at least 4 hours post-heart attack) [AHA 2008b], and no thrombus was found at autopsy. However, occasionally (16-27% of the time) post-mortem examinations do not reveal the coronary

artery thrombus/plaque rupture during acute heart attacks [Davies 1992; Farb et al. 1995]. This FF-EMT suffered sudden cardiac death either due to: 1) an acute heart attack without a thrombus being present at autopsy, or 2) a heart arrhythmia associated with any of the following conditions present in the FF-EMT: CAD, prior heart attack, biventricular hypertrophy, or cardiomegaly.

The FF-EMT did not report any episodes of chest pain (angina) during physical activity (on or off-the-job), nor during this episode. This lack of chest pain, however, does not rule out a heart attack, because in up to 20% of individuals, the first evidence of CAD may be myocardial infarction or sudden death [Thaulow et al. 1993; Libby 2008].

Epidemiologic studies have found that heavy physical exertion sometimes immediately precedes and triggers the onset of acute heart attacks [Tofler et al. 1992; Mittleman et al. 1993; Willich et al. 1993; Albert et al. 2000]. The FF-EMT had responded to a medical assist call, two smoke detector activation calls, a structure fire (where he performed forcible entry while wearing full turnout gear and SCBA), an automobile accident, and a call for downed wires. The forcible entry activities expended an estimated 11 metabolic equivalent of tasks (METs), which is considered very heavy physical activity [Gledhill and Jamnik 1992; Power-Up USA 2001]. 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]. Given the FF-EMT's underlying CAD, the physical stress of performing firefighting duties probably triggered a heart attack or a cardiac arrhythmia resulting in his sudden cardiac death.

Cardiomegaly/Biventricular Hypertrophy. On autopsy, the FF-EMT was found to have biventricular hypertrophy and an enlarged heart. These findings raise the possibility that, in addition to his atherosclerotic CAD, the FF-EMT could have had some type of mixed dilated/hypertrophic cardiomyopathy. However, the microscopic examination of the FF-EMT's heart tissue was not consistent with this diagnosis [Hughes 2004]. The more likely reason for the FF-EMT's biventricular hypertrophy is chronic ischemia from his underlying atherosclerotic CAD [Antman et al. 2008].

Screening Tests for Cardiac Disease – EKG and Echocardiogram. Could the FF-EMT's condition have been identified before his sudden death? The fact that he had no heart-related symptoms makes an earlier diagnosis difficult. However, he did have a "borderline" EKG in 2005 due to possible left atrial enlargement. A follow-up echocardiogram in 2005 revealed a mildly enlarged left atrium. It is unclear why this echocardiogram did not show the biventricular hypertrophy noted 2 years later at autopsy.

Screening Tests for Cardiac Disease – Stress Tests. Stress testing asymptomatic individuals for CAD is somewhat controversial. NFPA 1582 states, "Stress EKG with or without echocardiogram or radionuclide scanning

shall 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 that sub-maximal (85% of predicted heart rate) stress tests be used as a screening tool to evaluate a fire fighter's aerobic capacity. Maximal (e.g., symptom limiting/diagnostic) stress tests with imaging should be used for fire fighters with:

- abnormal screening sub-maximal tests
- cardiac symptoms
- known CAD
- Males over the age of 45, and females over the age of 55, with two or more risk factors for CAD. Risk factors are defined as hypercholesterolemia (total cholesterol >240 milligrams per deciliter [mg/dL]), hypertension (diastolic blood pressure >90 millimeters of mercury [mm Hg]), smoking, diabetes mellitus, or family history of premature CAD (heart attack or sudden cardiac death in a first-degree relative <60 years old).

If the stress test is negative, it should be repeated when clinically indicated, or at least every 5 years. Thus, based on NFPA guidance, the FF-EMT should have had a submaximal stress test.

The American College of Cardiology/American Heart Association (ACC/AHA) has also published stress test guidelines [Gibbons et al. 2002]. The ACC/AHA 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." Thus, based on ACC/AHA guidance, the FF-EMT should have had a symptom limiting stress test.

The U.S. Department of Transportation (DOT) has also provided guidance for those seeking medical certification for a commercial drivers license. The DOT expert medical panel recommended stress tests for asymptomatic "high risk" drivers [Blumenthal et al. 2007]. They define high risk drivers as those with any of the following:

- Diabetes mellitus
- Peripheral vascular disease
- Person above the age of 45 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, even those with risk factors for CAD. Rather, they recommend the diagnosis and treatment of modifiable risk factors (hypertension, high cholesterol, smoking, and diabetes) [USPSTF 1996]. The USPSTF indicates that there is insufficient evidence to recommend screening middle age and older

men or women in the general population, but notes that "screening individuals in certain occupations (pilots, truck drivers, etc.) can be recommended on other grounds, including the possible benefits to public safety."

Although this FF-EMT was asymptomatic and age 38, the ACC/AHA and the U.S. DOT guidance would recommend a symptom lmiting/diagnostic stress test. NFPA 1582 would recommend a submaximal stress test. If a stress test was performed, perhaps the FF-EMT's condition could have been identified and referred on for further evaluation and treatment.

Medical Requirements for Diabetic Fire-Fighters. NFPA 1582 provides guidance for fire department physicians to follow when assessing diabetic fire fighters. The standard states that fire fighters with diabetes mellitus that require treatment with insulin should be restricted from duty unless the member meets the following criteria:

- Is maintained by a physician knowledgeable in current management of diabetes mellitus on a basal/bolus regimen using insulin analogs
- Has demonstrated over a period of at least 1 year the motivation and understanding required to closely monitor nutritional therapy and insulin administration
- 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 based on 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
- Has a signed statement from an endocrinologist knowledgeable in management of diabetes mellitus as well as the essential job tasks and hazards of fire fighting that the fire fighter meets the following criteria:
  - Is maintained on a stable basal/bolus regimen using insulin analogs and has demonstrated over a period of at least 1 year the motivation and understanding required to closely monitor and control capillary blood glucose levels despite varied activity schedules through nutritional therapy and insulin administration
  - Has achieved stable control of blood glucose as evidenced by Hemoglobin A1C consistently less than 8 units when monitored at least twice yearly
  - Does not have an increased risk of hypoglycemia due to alcohol use or other predisposing factors

— Has had no episodes of severe hypoglycemia in the preceding 1 year, with no more than one episode of severe hypoglycemia in the preceding 5 years

— Is certified not to have a medical contraindication to fire fighting training and operations [NFPA 2007a].

The FF-EMT did not meet these criteria.

RECOMMENDATIONS

The NIOSH investigator offers the following recommendations to address general safety and health issues. It is possible these recommendations could have prevented the FF-EMT's sudden cardiac death at this time.

Recommendation #1: Conduct annual medical evaluations.

In 1996, the State of Massachusetts required annual fire fighter physical examinations to ensure fire fighters have the medical ability to perform duties without presenting a significant risk to the safety and health of themselves or others. Because the State did not provide funding, many fire departments have not complied with this regulation.

The Occupational Safety and Health Administration (OSHA)'s Hazardous Waste and Emergency Response standard outlines requirements for response to operations involving hazardous materials [29 CFR[1] 1910.120]. This standard requires annual medical evaluations for HazMat personnel (the FF-EMT was a HazMat responder). However, Massachusetts is not an OSHA State-Plan state, therefore, its public employees are not required to comply with OSHA standards.

NFPA and the IAFF/International Association of Fire Chiefs (IAFC) both recommend annual medical evaluations. Guidance regarding the content and frequency of these medical evaluations can be found in the reference documents [NFPA 2007a; IAFF, IAFC 2000]. However, applying this recommendation involves economic repercussions and may be particularly difficult to implement. NFPA 1500, Standard on Fire Department Occupational Safety and Health Program, paragraphs A.10.6.4 and A.11.1.1, addresses these issues [NFPA 2007b].

Recommendation #2: Phase-in a comprehensive wellness and fitness program for fire fighters to reduce risk factors for cardiovascular disease and improve cardiovascular capacity.

Guidance for fire department wellness/fitness programs is found in NFPA 1583, Standard on Health-Related Fitness Programs for Fire Fighters and in the IAFF/IAFC Fire Service Joint Labor Management Wellness/Fitness Initiative [NFPA 2008; IAFF, IAFC 2000]. Worksite health promotion programs have been shown to be cost effective by increasing productivity,

1Code of Federal Regulations. See CFR in references.

reducing absenteeism, reducing the number of work-related injuries, and reducing the number of work-related lost work days [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 recent study conducted by the Oregon Health and Science University reported a savings of over one million dollars 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 a reduction in occupational injury/illness claims, with additional savings expected from reduced future non-occupational healthcare costs [Kuehl 2007].

Recommendation #3: Perform an annual physical performance (physical ability) evaluation to ensure fire fighters are physically capable of performing the essential job tasks of structural firefighting.

NFPA 1500 requires Fire Department members who engage in emergency operations to be annually evaluated and certified by the Fire Department as having met the physical performance requirements established by the Fire Department [NFPA 2007b].

Recommendation #4: Provide fire fighters with medical clearance to wear self-contained breathing apparatus (SCBA) as part of the Fire Department's medical evaluation program.

The Occupational Safety and Health Administration (OSHA)'s Revised Respiratory Protection Standard requires employers to provide medical evaluations and clearance for employees using respiratory protection [29 CFR1 1910.134]. These clearance evaluations are required for private industry employees and public employees in States operating OSHA-approved State plans. Massachusetts does not operate an OSHA-approved State plan; therefore, public sector employers (including volunteer/paid fire departments) are not required to comply with OSHA standards. Nonetheless, we recommend voluntary compliance with this OSHA standard.

Recommendation #5: 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 2000]. These guidelines recommend confirming tube placement by primary and secondary methods. Primary confirmation is by 5-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, the FF-EMT had bilateral breath sounds confirmed by auscultation and the tube became visibly fogged, however, according to records obtained by the NIOSH investigator, secondary confirmation was not

performed. This recommendation does not imply that the endotracheal tube was misplaced or that it in any way contributed to the FF-EMT's death. We raise this issue only to ensure that future ALS resuscitation efforts follow AHA guidelines.

Recommendation #6: Follow NFPA 1582 guidelines for when and how to restrict fire fighters with specific medical conditions.

Insulin-dependent diabetes mellitus compromises a fire fighter's ability to have prolonged periods of extreme physical exertion without the benefit of warm-up, scheduled rest breaks, meals, access to medication(s), or hydration. According to NFPA 1582, the insulin-dependent diabetic fire fighter should be restricted from duty unless the fire fighter meets certain criteria, as noted above [NFPA 2007a]. NFPA 1582 also states that narcotic pain medications compromise a fire fighter's ability to safely perform almost every essential job task due to "alterations in mental status including vigilance, judgment, and other neurologic functions." The standard recommends restricted duty for fire fighters taking narcotics [NFPA 2007a].

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Appendix A – Autopsy Findings

- Cardiomegaly (heart weighed 636 grams [g]; normal weight is <400 g) [Siegel 1997]
- Atherosclerotic CAD
  - — Severe (95%) focal narrowing of the right coronary artery
  - — Severe (90%) focal narrowing of the left circumflex coronary artery
  - — Moderate (70%) focal narrowing of the left anterior descending coronary artery
- Focal remote myocardial fibrosis of the posterior septum consistent with a previous ischemic event
- Biventricular hypertrophy
  - — Right ventricle measured 1 centimeter (cm); normal at autopsy is 0.3-0.5 cm [Klatt 2008]
  - — Left ventricular wall thickened (1.6 cm; normal by autopsy is 0.76-0.88 cm [Colucci and
  - — Braunwald 1997]; normal by echocardiographic measurement is 0.6-1.1 cm) [Armstrong and Feigenbaum 2001]
- Right ventricular dilatation
  - — Right ventricle internal diameter measured 5 cm; normal is 0.7-2.3 cm [Armstrong and Feigenbaum 2001]
- Normal cardiac valves
- No evidence of thrombus (blood clot) in the coronary arteries, although the left circumflex coronary artery showed acute hemorrhage into an atheromatous plaque
- No evidence of a pulmonary embolus (blood clot in the lung arteries)
- Microscopic examination of the heart revealed myocyte hypertrophy (enlarged cardiac muscle cells), marked two-vessel coronary artery atherosclerosis, and an area of myocardial fibrosis consistent with a previous (old) heart attack in the interventricular septum area
- Negative drug and alcohol tests
  - — (Amphetamines, barbiturates, benzodiazepines, methadone, opiates, cocaine, fentanyl, oxycodone, phencyclidine, propoxyphene, cannabinoids, tricyclic antidepressants, ethanol, isopropanol, methanol, acetone)

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