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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 December, 2012

Lieutenant Suffers Fatal Heart Attack During a Fire in a Commercial Structure – New York

Executive Summary

On April 16, 2012, a 47-year-old male career lieutenant (LT) responded with his crew to a commercial fire. After operating on scene for about an hour, a chief officer noticed that the LT was not looking well and summoned the Rapid Intervention Team (RIT) to remove the LT from the building. Once removed from the building, the LT's care was transferred to on-scene Emergency Medical Service (EMS) personnel. The LT reported that he was fine, but during the EMS initial evaluation, the LT had seizure-like activity and became unresponsive. A cardiac monitor revealed ventricular tachycardia and the LT was defibrillated (shocked) but this did not result in a stable heart rhythm. Despite cardiopulmonary resuscitation (CPR) and advanced life support on scene, en route to the hospital, and in the emergency department (ED), the LT died. The death certificate and autopsy report listed the immediate cause of death as "acute thrombotic occlusion of left anterior descending coronary artery" due to "atherosclerotic cardiovascular disease." NIOSH investigators conclude that the physical exertion associated with his work at the fire triggered the LT's myocardial infarction (heart attack) and sudden cardiac death. NIOSH offers the following recommendations to reduce the risk of heart attacks and sudden cardiac arrest among fire fighters at this and other fire departments (FD) across the country.

Perform symptom limiting exercise stress tests on FFs at increased risk for coronary heart disease and sudden cardiac events.

Review policies and procedures to ensure appropriate use of respiratory protection on the fire ground.

Consider a more comprehensive annual physical performance (physical ability) evaluation.

Introduction & Methods

On April 16, 2012, a 47 year-old career LT suffered a heart attack and sudden cardiac death while working at a commercial fire. NIOSH was notified of this fatality on April 17, 2012, by the U.S. Fire Administration. NIOSH contacted the affected FD on May 25, 2012, to obtain additional information and to schedule the investigation. On July 9, 2012, a contractor for the NIOSH Fire Fighter Fatality Investigation Team (the NIOSH investigator) conducted an on-site investigation of the incident.

During the investigation, the NIOSH investigator interviewed the following people:

- Deputy Assistant Chief of Safety
- Battalion Chiefs (BC) who led an internal investigation
- Chief Medical Officer and Medical Director
- Union representatives

The NIOSH investigator reviewed the following documents in preparing this report:

- FD general operating procedures
- FD internal investigative report
- Witness statements taken shortly after the incident
- Ambulance pre-hospital care report
- Death certificate
- Medical examiner's report
- FD medical records
- Hospital records

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Investigative Results

Incident. On April 16, 2012, the LT reported to work at 0900 hours. The crew's first response of the day was a medical call at 1245 hours. While the LT and his crew were operating at that medical call, the FD received an alarm reporting a fire in a commercial structure (1300 hours). At 1302 hours the LT's engine became available and they were assigned to the fire as the third-due engine (normally the LT's engine would be first-due for this location). The structure was a two-story Class 1 commercial/warehouse measuring 350 feet wide by 650 feet deep and containing four occupancies with different entrances (Photo 1). It was a warm day with a temperature of approximately 85 degrees Fahrenheit and 40% relative humidity [Wunderground 2012].

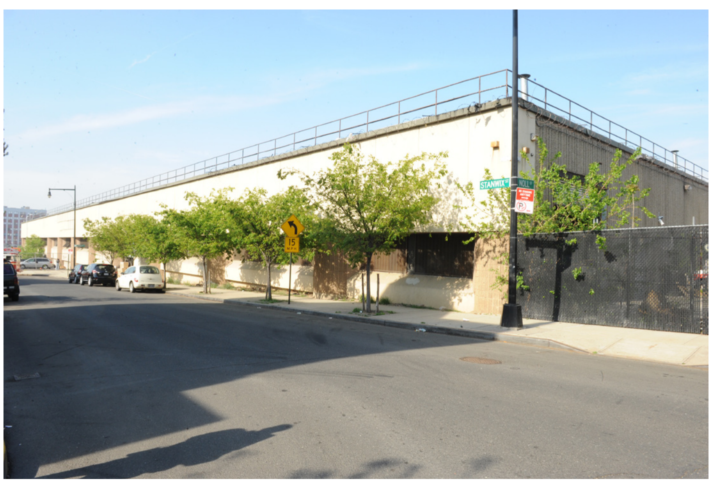

Photo 1. Commercial structure in which fire occurred. The fire occurred in a 2-story, Class 1 commercial building.

The LT and his crew arrived at the fire scene at 1305 hours. At this time occupants reported smelling smoke but no smoke was showing. The LT entered the building to determine accessibility, route for the hoseline, and location of the smoke smell. For the next 18 minutes other on-scene crews searched for the fire. At 1323 hours the LT was told by a police officer that the fire was located on the "D side" of the building. The LT requested permission to reposition his apparatus to that position. As his crew moved the engine, the LT began to walk through the building to meet his crew at their new position on the D side of the building.

At 1326 hours an officer from another engine located the fire and shortly thereafter a ladder company officer suggested access from D side of the building – the position of the LT's engine. At 1329 hours a ladder company firefighter reported heavy smoke conditions and requested ventilation. The ladder officer notified command that the sprinkler was activated and they had smoke conditions but no visible fire. At 1330 hours the Incident Commander (IC) transmitted a working fire with fire smoldering in a storage room and requested additional units. At 1334 hours, the first-due ladder company notified command that it looked like the sprinkler system had knocked the fire down but the smoke would not lift until the sprinklers were turned off. The IC requested that a smoke ejector be set up.

At 1336 hours the second-due BC arrived on scene and assumed the role of Interior Chief of Operations (all-hands chief). At 1342 hours a Deputy Chief assumed the role of Incident Commander (IC) and the BC (previous IC) entered the building to assist the all hands chief inside the structure. A few minutes later, the first- and second-due engines notified command that they had located the fire in a raised storage area and "there's a good amount of it." (Photo 2) The first- and second-due engines stretched 2½-inch hoselines to the fire. At 1344 hours one of the engine companies reported that boxes (subsequently found to contain plastic) were burning. At 1346 hours a BC inside the structure reported to IC that the fire was not extin-

Investigative Results (cont.)

guished, but the sprinklers had knocked it down and they now had water on the fire.

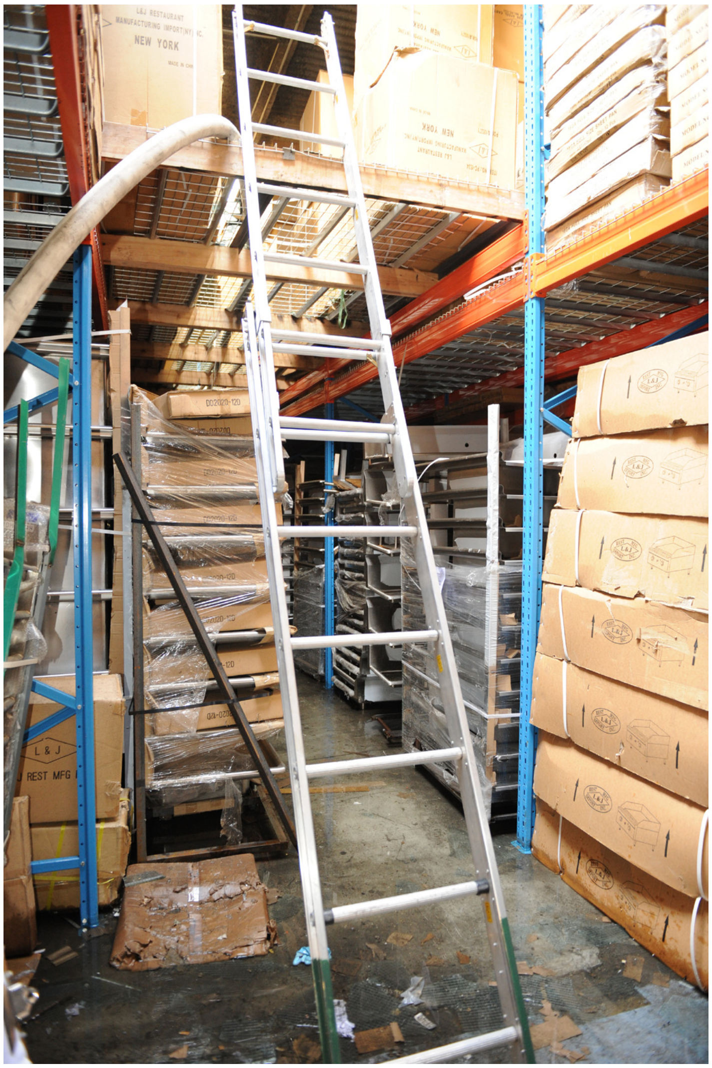

Photo 2. Ladder leading to "catwalk". A ladder provided access to the "catwalk" that provided access to raised storage area where boxes of printed material were stored.

At 1348 hours the LT and his crew began to stretch a 2½ inch line from their engine. At 1350 hours, the IC requested additional units. The LT and his crew, along with the fourth-due engine continued to stretch hoseline. Together these two crews stretched 14 lengths of 2½ inch line while wearing full personal protective equipment [turnout pants and coat, flash hood, gloves, boots, helmet and self-contained breathing apparatus (SCBA).

At 1406 hours the LT and his crew completed stretching their line and at 1414 hours were assigned to take over the hoseline from the first and second-due engines. The LT and his crew ascended the ladder, advanced down a "catwalk" (an illegal mezzanine-like structure that that provided access to remote areas in the rack storage) and took over the hoselines (Photos 3 and 4).

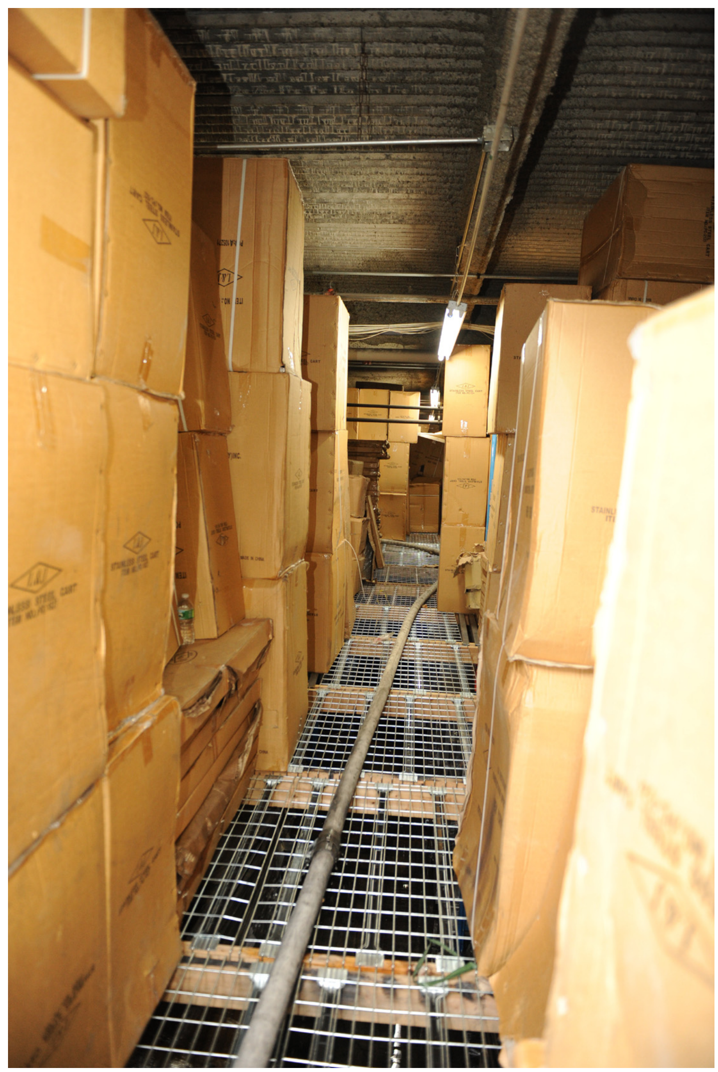

Photo 3. Hoseline stretched down the "catwalk". The attack line was stretched down the catwalk leading to the fire area.

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Investigative Results (cont.)

Photo 4. The fire area. The fire area contained cardboard boxes containing plastic shelving and restaurant equipment.

As the LT neared the top of the ladder on the rack storage unit, a Senior Chief asked him how he was feeling (1432 hours). The LT responded that he did not feel well; he was lightheaded and dizzy. The Chief requested that the RIT assist the LT and that the medics be notified of a member feeling light-headed. At 1435 hours the RIT team, assisted by others, placed the LT in a Stokes stretcher and lowered the LT/stretcher down a ladder and out the front of the building (A side). While being removed from the building, the LT was provided with air from a RIT pack a air cylinder.

At 1444 hours the LT was brought out of the building and transferred to an advanced life support ambulance unit. The LT was alert and oriented and told emergency medical service (EMS) that "I'm fine." The initial assessment revealed a heart rate of 104 beats per minute and a respiration rate of 16 breaths per minute. The LT had no signs of trauma, the airway was patent, the voice was not scratchy or raspy and there was no soot around the airway. A Rad 57® (carbon monoxide [CO] monitor) revealed 98% oxygen saturation (normal), but a 15% carboxyhemoglobin (COHb) saturation level (elevated). The LT was placed on oxygen using a non-rebreather mask.

At 1448 hours the LT had seizure-like activity and an anti-seizure medication was administered. At 1450 hours a cardiac monitor revealed ventricular tachycardia with a pulse and he received a synchronized cardioversion at 160 joules. Approximately 30 seconds later, the LT's rhythm changed to ventricular fibrillation. At 1452 hours the ambulance left the scene for the nearest hospital. Attempts to intubate the LT were unsuccessful and the LT received a second shock at 200 joules.

At 1500 hours the ambulance arrived at the hospital and care was transferred to the ED staff. At this time the LT's heart rhythm was pulseless electrical activity. He was defibrillated and his rhythm briefly changed to ventricular fibrillation before returning to pulseless electrical activity and then asystole (no heart beat). Despite advanced cardiac life support measures, including

Investigative Results (cont.)

the use of intravenous cardiac drugs, resuscitation efforts were unsuccessful. At 1532 hours the LT was pronounced dead and resuscitation efforts were discontinued.

Medical Findings. The death certificate, completed by the Deputy Chief Medical Examiner for the County, listed the immediate cause of death as "acute thrombotic occlusion of left anterior descending coronary artery" due to "atherosclerotic cardiovascular disease." The autopsy, also conducted by the Deputy Chief Medical Examiner, revealed that in addition to a thrombus (blood clot) in the left anterior descending coronary artery, the LT also had left ventricular concentric hypertrophy (a finding consistent with longstanding hypertension). See Appendix A for a more complete description of pertinent autopsy findings.

The LT's medical records from his primary care physician were not available to NIOSH at the time of this investigation. The FD medical records indicate that the LT had a history of hypertension, high blood cholesterol, sleep apnea, and chronic sinusitis. He was 68 inches tall and weighed about 250 pounds, giving him a body mass index (BMI) of 38 kilograms per meter squared. A BMI of greater than or equal to 30.0 kilograms per meter squared is considered obese [CDC 2011]. The LT reported to the medical team doing his evaluation that he was a non-smoker and that he had begun an exercise program.

Description of the Fire Department

At the time of the FF's death, the FD consisted of approximately 10,787 Uniformed Fire Fighters and Fire Officers, 3,200 EMTs and Paramedics, 120 Fire Marshals, 301 Fire Inspectors, and 1,599 administrative support personnel serving a population of eight million residents in a geographic area of 322 square miles. The FD had over 300 fire stations and other buildings.

In 2011, the FD responded to 488,017 calls, including 25,380 structural fires, 15,729 non-structural fires, 206,798 non-fire emergencies, 216,083 medical emergencies, and 24,027 malicious false alarms. Included in the responses were 2,652 serious incidents involving 2,453 all hands, 164 second alarms, 19 third alarms, 10 fourth alarms, and 6 fifth alarms or greater incidents. Prior to the incident, the LT had responded to one medical call during his shift.

Training. The FD requires all fire fighter candidates to complete an application, background checks and pass the National Candidate Physical Ability Test (CPAT) prior to being offered conditional employment. Candidates must then pass a pre-placement physical examination prior to being fully hired. Newly hired fire fighters attend an 18-week probationary training program at the Bureau of Training, after which they are certified fire fighters. This training includes certification as a first responder, which includes CPR and automated external defibrillator (AED). The State of NY also requires 100 hours of training per year for annual recertification as a career fire fighter. The LT was certified as a Fire Fighter I, Emergency Apparatus Driver/Operator, and First Line Supervisor; he had 17 years of firefighting experience.

Pre-placement Medical Evaluations. The FD requires a pre-placement medical evaluation for all

Description of the FD (cont.)

fire fighter candidates. The pre-placement evaluation includes the following items:

- A complete medical history and questionnaire
- Height, weight, and vital signs
- Physical examination
- Vision test
- Hearing test
- Blood tests: Complete blood count (CBC), chemistry panel (SMA 20) which includes cholesterol and triglyceride measurement
- Urinalysis
- Urine drug test
- Spirometry (lung function tests)
- Resting electrocardiogram (EKG)
- Chest X-ray
- Skin test for tuberculosis (PPD)
- Immunizations administered if proof of vaccination cannot be provided (hepatitis B, measles, mumps, & rubella (MMR), tetanus if a booster had not been given within the past ten years)
- Fire fighters assigned to waterways also are offered a hepatitis A vaccine.

These evaluations are performed by the FD Medical staff, who make a decision regarding medical clearance for firefighting duties. New hires are also required to complete a physical fitness and strength test at the time of the medical evaluation. The aerobic test involves 3 minutes on a stair stepping machine at 60 steps per minute. The heart rate is recorded and must be less than 90% of maximum (220 minus age).

Periodic Medical Evaluations. The FD requires annual medical evaluations for all fire fighters. Components of this evaluation are identical to the pre-placement evaluation with the following exceptions: (1) the chest X-ray is required only every 2 years and (2) the drug screen is not required. This LT had his last FD medical evaluation in August 2011. The LT reported to the medical team that he was being treated for hypertension and high cholesterol. Medical notes also indicate that the LT was being treated for sleep apnea. Laboratory results from his last medical evaluation indicate that his blood pressure was well-controlled (110/80 millimeters of mercury) as was his total cholesterol (197 milligrams per deciliter [mg/dL]; desirable = <200; borderline high = 200̃239). Although the LT's total cholesterol was within normal limits, he had low levels of the "good" cholesterol (HDL cholesterol = 38 mg/dL; low is <40; high is ≥60) and elevated levels of the "bad" cholesterol (LDL cholesterol = 109 mg/dL; optimal is <100; near optimal/above optimal is 100̃129). The LT also had elevated triglyceride levels (triglycerides = 252 mg/dL; normal is <150; high is 200̃499). The chest x-ray and EKG were within normal limits. The LT completed the annual aerobic test in August of 2011 and had a heart rate of 156 after completing the 3-minute stairstep exercise.

Medical Clearance and Fitness/Wellness Programs. A fire fighter injured at work must be evaluated and cleared for "return to work" by a physician in the FD's medical clinic. A fire fighter who misses work for one or more days because of an illness (work-related or not) must also be evaluated and cleared for "return to work" by the FD medical staff.

All fire houses have exercise (strength and aerobic) equipment. The FD has voluntary smoking cessation and weight control programs, and a voluntary non-punitive wellness/fitness program. It is unclear whether the LT participated in the FD's wellness/fitness program although the LT reported on his last health history questionnaire that he was on a diet/exercise program (in addition to medication) to treat his hypercholesterolemia and hypertension.

Discussion

Coronary Heart Disease (CHD) and the Pathophysiology of Sudden Cardiac Death. The LT suffered a myocardial infarction and subsequent cardiac arrest after performing approximately 90 minutes of firefighting work. The most common risk factor for cardiac arrest and sudden cardiac death is CHD, defined as the build-up of atherosclerotic plaque in the coronary arteries [AHA 2010]. The LT had multiple risk factors for CHD (hypertension, high cholesterol, obesity). At autopsy, he was found to have an occlusive thrombosis in his left anterior descending artery confirming a myocardial infarction (heart attack).

The narrowing of the coronary arteries by atherosclerotic plaques occurs over many years, typically decades [Libby 2005]. However, the growth of these plaques probably occurs in a nonlinear, often abrupt fashion [Shah 1997]. As in this case, most heart attacks occur when a vulnerable plaque ruptures, causing a blood clot to form and occlude a coronary artery.

Physiological Stress of Firefighting. Firefighting is widely acknowledged to be physically demanding. Firefighting activities require fire fighters to work at near maximal heart rates for long periods. An increase in heart rate typically occurs in response to the initial alarm and persists throughout the course of fire suppression activities [Barnard and Duncan 1975; Lemon and Hermiston 1977; Manning and Griggs 1983; Smith et al. 2001]. Even when energy costs are moderate (as measured by oxygen consumption) and work is performed in a thermoneutral environment, heart rates may be high (over 170 beats per minute) owing to the insulated properties of the personal protective clothing [Smith et al. 1995].

Epidemiologic studies in the general population have found that heavy physical exertion can trigger a heart attack and/or sudden cardiac death [Tofler et al. 1992; Mittleman et al. 1993; Willich et al. 1993; Albert et al. 2000]. Epidemiologic studies among fire fighters have shown that fire suppression, training, alarm response, or strenuous physical activity on the job, in the preceding 12 hours, increases the risk for a sudden cardiac event [Kales et al. 2003; Hales et al. 2007; Kales et al. 2007]. Some authors have also suggested that activation of the sympathetic nervous system (adrenaline surge) associated with alarm response and emergency operations may contribute to the triggering of cardiac events in fire fighters [Soteriades et al. 2011]. Increases in heart rate of 12 to 117 bpm have been reported within 15̃30 seconds of an alarm response [Barnard and Duncan 1975]. Furthermore, approximately 13% of line of duty deaths due to cardiac events occur during the emergency response [Kales et al. 2007].

The LT suffered a myocardial infarction and subsequent cardiac arrest after operating at a commercial structure for approximately 90 minutes. His tasks including walking the building in full PPE to determine the best way to stretch the hose line, searching for the seat of the fire, and operating in a tight area on a raised storage rack with his crew. NIOSH concludes that the stress of firefighting likely triggered the LT's heart attack and subsequent sudden cardiac death.

Left Ventricular Hypertrophy. The autopsy revealed that the LT had concentric LVH. Hypertrophy of the left ventricle is relatively common among individuals with long-term hypertension, a heart valve problem, or chronic cardiac ischemia (reduced blood supply to the heart muscle) [Siegel 1997]. The LT had a history of hypertension (unknown duration) which is likely responsible for the LVH. Left ventricular hypertrophy in-

Discussion (cont.)

creases the risk for sudden cardiac death [Levy et al. 1990].

Carbon Monoxide, Carboxyhemoglobin Levels, and Carbon Monoxide Poisoning. Carbon monoxide (CO) is a component of fire smoke. When inhaled, CO crosses the alveolar (lung) membrane and binds to hemoglobin, forming COHb. The COHb reduces the availability of oxygen to other tissues and disrupts the intercellular use of oxygen which can lead to hypoxia (inadequate oxygen supply) [Alonso et al. 2003]. The brain and the heart are the organs most vulnerable to hypoxia. Symptoms/signs associated with CO poisoning include headache, dizziness, weakness, nausea, confusion, fast heart rate, and shortness of breath [Ernst and Zibrak 1998]. The LT reported being lightheaded and dizzy while in the raised storage area. These symptoms are consistent with both CO poisoning and an acute myocardial infarction.

COHb levels in the blood are used to assess CO exposure and CO poisoning. COHb levels, however, do not correlate well with clinical findings [Kindwall 1994; Piantadosi 2002]. CO levels in non-smokers are typically less than 3.0% [Ernst and Zibrak 1998]. A portable fingertip carboxyhemoglobin saturation monitor (a RAD 57®) indicated the LT's COHb saturation level was 15% shortly after he was removed from the building. However, a blood sample at autopsy revealed a COHb level of less than 5%. This discrepancy could be due to a reduced COHb half-life due to adequate CPR with 100% oxygen, to inaccurate fireground reading associated with soot covered hands, or to validity issues associated with the field use of use of the RAD 57® [Maisel and Lewis 2010; Touger et al. 2010; Roth et al. 2011]. While CO intoxication is a known cause of cardiac arrhythmias and coronary ischemia, the effect of CO on acute plaque rupture is unknown. However, cigarette smoke, of which CO is a component, is associated with myocardial infarction and sudden death, presumably due to platelet aggregation and thrombus formation [Zevin et al. 2001; Inoue 2004].

Occupational Medical Standards for Structural Firefighting. To reduce the risk of sudden cardiac arrest or other incapacitating medical conditions among fire fighters, the National Fire Protection Association (NFPA) developed NFPA 1582, Standard on Comprehensive Occupational Medical Program for Fire Departments [NFPA 2007a]. This voluntary industry standard provides (1) the components of a preplacement and annual medical evaluation and (2) medical fitness for duty criteria. The LT had a history of hypertension and high cholesterol and was obese. But these conditions, by themselves, should not trigger fire fighter duty restrictions. However, the number and severity of these CHD risk factors could have warranted additional screening such as an exercise stress test. Recommendations for conducting exercise stress tests on asymptomatic individuals without known heart disease are varied and controversial. The following paragraphs summarize the positions of widely recognized organizations on this topic.

National Fire Protection Association 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 evalu-

Discussion (cont.)

ate 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 deciliter), hypertension (systolic blood pressure greater than 140 mmHg or diastolic blood pressure greater than 90 mmHg), 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 (USDOT) 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 CHD
- Framingham risk score predicting a 20% CHD 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, they recommend 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."

Discussion (cont.)

Although the LT's CHD risk factors were well controlled, it could be argued that a symptom-limiting exercise stress test would have been appropriate [NFPA 2007a; Gibbons et al. 2002; Blumenthal et al. 2007]. However, exercise stress tests in asymptomatic individuals are known to have false negative test results and, thus, may have failed to detect the LT's underlying CAD.

Recommendations

NIOSH investigators offer the following recommendations to reduce the risk of on-the-job heart attacks and sudden cardiac arrest among fire fighters.

Recommendation #1: Perform symptom-limiting exercise stress tests on FFs at increased risk for CHD and sudden cardiac events.

Firefighters with multiple or severe CHD risk factors or a high Framingham score are at increased risk of a sudden cardiac event [NHLBI 2010]. Because the LT was over 45 years of age and had multiple risk factors (obesity, treated hypertension, treated high cholesterol), an exercise stress test may have been warranted.

Recommendation #2: Review policies and procedures to ensure appropriate use of respiratory protection on the fire ground.

Smoke, vapor, or fumes from a fire or hazardous material incident contains many toxic components [Lees 1995]. Some of these components may have immediate effects on the unprotected fire fighter (e.g., CO, hydrogen cyanide, etc.) while others may have chronic effects caused by years of exposure (e.g., smoke particulates or benzene) [Lees 1995]. SCBA must be worn when a fire

Recommendations (cont.)

fighter enters an immediately dangerous to life or health (IDLH) environment (e.g. fire smoke) and should be worn when a fire fighter enters a potential IDLH environment (unknown smoke conditions). The LT worked in an area of light to moderate smoke conditions for approximately 90 minutes while searching for the fire and stretching hoselines. During this time he used only approximately 1000 psi of air from his cylinder. Although results from the COHb tests are conflicting, the LT probably had some CO exposure. While it is unclear if CO played a role in triggering the LT's acute heart attack, given the importance of protecting the respiratory system of firefighters, the FD should review their policies and procedures to ensure appropriate SCBA use.

Recommendation #3: Consider a more comprehensive annual physical performance (physical ability) evaluation.

NFPA 1500, Standard on Fire Department Occupational Safety and Health Program recommends that the FD annually evaluate and certify FD members who engage in emergency operations as having met the physical performance requirements identified in Paragraph 10.2.3 of the standard [NFPA 2007b]. This is recommended to ensure that fire fighters are physically capable of performing the essential job tasks of structural fire fighting. Although the FD estimates the aerobic capacity during the annual FD medical evaluation, the FD should consider a more comprehensive evaluation as recommended by NFPA 1500.

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Investigator Information

This incident was investigated by the NIOSH Fire Fighter Fatality Investigation and Prevention Program, Cardiovascular Disease Component located in Cincinnati, Ohio. Denise L. Smith, Ph.D, led the investigation and coauthored the report. Dr. Smith is professor of Health and Exercise Sciences, and Director of the First Responder Health and Safety Laboratory at Skidmore College. She is a member of the NFPA Technical Committee on Occupational Safety and Health. Dr. Smith was working as a contractor with the NIOSH Fire Fighter Fatality Investigation and Prevention Program, Cardiovascular Disease Component during this investigation. Thomas Hales, MD, MPH, provided medical consultation and coauthored the report. Dr. Hales is a member of the NFPA Technical Committee on Occupational Safety and Health, and Vice Chair of the Public Safety Medicine Section of the American College of Occupational and Environmental Medicine (ACOEM).

Lieutenant Suffers Fatal Heart Attack During a Fire in a Commercial Structure – New York

Appendix A

Autopsy Findings

- Hearty Size/Structure
  - Heart weight = 486 grams
  - Concentric left ventricular hypertrophy
    - Interventricular septum = 1.6 cm (normal by autopsy 0.76–0.88 cm [Colucci and Braunwald 1997]
- Coronary Arteries
  - Moderate atherosclerotic stenosis:
    - 40-50% proximal left anterior descending coronary artery
    - 60-70% distal left anterior descending coronary artery
    - 40-50% circumflex coronary artery
    - 30-40% right coronary artery
  - Occlusive recent thrombus in proximal left anterior descending coronary artery
  - Rupture of noncalcified atheromatous/atherosclerotic plaque

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