2013
01

Death in the line of duty...

NIOSH
Fire Fighter Fatality Investigation and Prevention Program

A summary of a NIOSH fire fighter fatality investigation *June, 2013*

Captain Suffers Sudden Cardiac Death While On-Duty – Tennessee

Executive Summary

On August 20, 2012, a 49-year-old male career fire captain ("Captain") was scheduled to work a 24-hour shift. The Captain arrived for duty at the fire station at 0700 hours. At 0727 hours the Captain complained of indigestion and chest pain. As he went to obtain an antacid in the bunkroom, he asked his Lieutenant to call for an ambulance. A few moments later crew members heard what sounded like snoring and found the Captain lying unresponsive in the hallway. An automated external defibrillator (AED) was obtained as an ambulance was called. Cardiopulmonary resuscitation (CPR) was begun (0728 hours) as three AED shocks were administered without improvement in his clinical status. The ambulance arrived at 0738 hours and advanced life support was begun. The Captain was transported to the hospital's emergency department where advanced life support continued for 15 minutes. Despite CPR and advanced life support on the scene, in transport, and at the hospital, the Captain died at 0817 hours. The death certificate and the autopsy listed "acute coronary insufficiency" as the cause of death. Given the Captain's underlying cardiovascular disease, NIOSH investigators concluded that an arrhythmia or heart attack probably triggered his sudden cardiac death.

The following recommendations were not related to the Captain's death. Nonetheless, NIOSH investigators offer these recommendations to strengthen the FD's comprehensive safety and health program.

Incorporate exercise stress tests into the fire department medical evaluation program for fire fighters at increased risk for coronary heart disease (CHD).

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

Discontinue exercise stress tests on asymptomatic young fire fighters with no risk factors for coronary heart disease (CHD).

Introduction & Methods

On August 20, 2012, a 49-year-old male career captain died soon after reporting to his fire station for a 24-hour shift. NIOSH contacted the affected fire department (FD) on September 25, 2012, to gather information and on January 9, 2013, to initiate the investigation. On January 23, 2013, a safety and occupational health specialist from the NIOSH Fire Fighter Fatality Investigation and Prevention Program conducted an on-site investigation of the incident.

During the investigation, NIOSH personnel interviewed the following people:

- Fire Chief
- FD Safety Officer
- FD Training Officer
- Union Executive Board member
- FD contract physician
- Crew members
- Captain's family

Captain Suffers Sudden Cardiac Death While On-Duty – Tennessee

Introduction & Methods (cont.)

NIOSH personnel reviewed the following documents:

- FD standard operating procedures
- FD annual report for 2012
- FD incident report
- Emergency medical service (ambulance) report
- Hospital emergency department report
- Death certificate
- Autopsy
- FD medical evaluation records
- Primary care physician records

Investigative Results

Incident. On August 20, 2012, the Captain reported to his fire station at 0700 hours for a 24-hour shift. This was his first day back to work after 2 months of medical leave due to knee surgery. Approximately 27 minutes into his shift, he told his Lieutenant that he was not feeling well due to indigestion and chest pain. He asked the Lieutenant to call an ambulance as he walked toward the bunkroom to obtain an antacid. Just after the Captain left room, the Lieutenant heard what sounded like snoring. Crew members found the Captain lying in the hallway, unresponsive. Assessment revealed no breathing and no pulse. CPR was begun as an AED was retrieved and applied. The AED recommended three shocks which were administered between 0729 – 0737 hours. (Note – NIOSH investigators noted an 8- minute discrepancy between the time stamp of the AED tracings and the actual time per dispatch and fire fighter interviews and notes).

The ambulance arrived at 0738 hours and paramedics found the Captain with no pulse or respirations; CPR was in progress. An intravenous line was placed and cardiac resuscitation medications were administered. CPR continued throughout as the cardiac monitor revealed asystole (no heart beat). After an unsuccessful intubation attempt, a Combitube® was placed and 100% oxygen was administered. The Captain was placed into the ambulance which departed the scene at 0748 hours en route to the nearest hospital.

The ambulance arrived at the hospital at 0758 hours. The cardiac monitor continued to show asystole. External cardiac pacing was attempted without capture. CPR and advanced life support efforts continued until 0817 hours, when the Captain was pronounced dead by the attending physician, and resuscitation efforts were discontinued.

Medical Findings. The death certificate and the autopsy listed "acute coronary insufficiency" as the cause of death with "possible plaque hemorrhage in the middle third of the left anterior descending coronary artery." Pertinent findings from the autopsy are listed in Appendix A.

Since 2000, the Captain had periodic FD medical evaluations that identified the following medical conditions:

- Hyperlipidemia and hypertriglyceridemia: diagnosed in 2007 and treated intermittently with a cholesterol-lowering medication with fair to poor control (most recent values in February 2012 included cholesterol 248 milligrams per deciliter [mg/dL] [normal is 100-199], triglycerides 234 mg/dL [normal is 0-149], high density lipoprotein 42 mg/dL [normal is >39], and low density lipoprotein 159 [normal is 0-99]).
- Type II diabetes mellitus: first noted in 2007 but diagnosed in 2010 and treated with an oral glucose-lowering medication with fair control (glucose range 100–115 mg/dL, hemoglobin A1c range 6.3–6.5).

Investigative Results (cont.)

- Hypertension: diagnosed in 2011. The Captain was prescribed a blood pressure-lowering medication including a beta blocker, which achieved fair blood pressure control (133/73 millimeters of mercury at his commercial driver's license medical evaluation on August 16, 2012).

The Captain had a negative exercise stress test in 2007, but an abnormal electrocardiogram (EKG) in 2011 prompted an imaging exercise stress test. The Captain exercised for 10 minutes, 4 seconds on the Bruce protocol, achieving 13 metabolic equivalents (METs) and 89% of his maximal predicted heart rate. The test was stopped due to fatigue. He had no angina, normal blood pressure response, no ischemic changes, no arrhythmias, and normal pump function (left ventricular ejection fraction of 60%).

In May 2012, the Captain injured his knee requiring surgery in June 2012. He was on medical leave until August 16, 2012, when his orthopedist cleared him to work on August 20, 2012. However, the afternoon of August 16, the Captain had an episode of substernal chest pain. A walk-in clinic did an EKG which revealed new nonspecific inferolateral ST changes and nonspecific T wave changes. The Captain had taken an aspirin prior to arrival in the clinic and was pain free at the time of the EKG. The clinic physician advised him to be transported via ambulance to the emergency department. The Captain stated he had a primary care physician appointment later that afternoon, and that his wife would drive him to the clinic. He signed out against medical advice and left the clinic. He visited the second clinic that afternoon for a commercial driver's license medical evaluation. The results of the medical evaluation were normal. The Captain had forgotten to take his antihypertensive medication that morning and took the medication prior to the visit to the clinic. On August 17, the Captain visited the City physician for return to duty clearance from his knee injury. No mention was made of the chest pain evaluated in the walk-in clinic the previous day. The City physician cleared the Captain to return to duty on August 20, 2012 as recommended by his orthopedist.

The Captain was 69 inches tall and weighed 160 pounds, giving him a "normal" body mass index of 23.6 kilograms per meter squared [CDC 2011]. Prior to August 2012, the Captain never reported symptoms suggestive of CHD. He participated in daily exercise by either walking, cycling, or playing basketball.

Description of the Fire Department

At the time of the NIOSH investigation, the FD consisted of 19 fire stations with 423 career uniformed personnel serving 150,000 residents in a geographic area of 137 square miles.

Membership and Training. The FD requires new full-time fire fighter applicants to be 21 years of age, have a valid state driver's license, have a high school diploma or a General Equivalency Diploma, pass a written test, pass an eleven-station candidate physical ability test (PAT) (described below), pass an interview, and pass a polygraph. The successful applicant must then pass a pre-placement medical evaluation. After receiving a conditional job offer, the new hire is placed in the next 6-month fire academy to be trained as a Fire Fighter 1 and 2, hazardous materials operations and technician, vehicle rescue technician, and emergency medical technician-intermediate. The new hire undergoes daily

Description of the FD (cont.)

physical fitness training during the fire academy. Upon graduation, the new hire is placed on a shift and is on probation for 1 year and works 24 hours on-duty/24 hours off-duty for two tours, then 24 hours on-duty/4 days off-duty (three shifts in five days, then off-duty for four shifts) 0700-0700 hours. New hires are not allowed to use tobacco products. The Captain was certified as a Fire Fighter 1 and 2, Driver/Operator, EMT, Instructor, Wildland Fire Fighter, Fire Instructor, Technical Rescuer, and Hazardous Materials Technician. He had 25 years of fire fighting experience including 12 years as a Captain.

Physical Ability Tests. Candidates are given a preparation/training guide prior to attempting the PAT. The PAT is a timed evaluation consisting of the following eleven stations: hose drag, hose carry up stairs, rope equipment raise simulator, 300-feet walk, scale a 4-foot wall, ladder raise, ladder climb and descent, stair climb with a weight, forcible entry, tunnel crawl, and dummy drag (Appendix B). Candidates must complete the FD's candidate PAT prior to completing a formal application for hire. Members are also required to pass the PAT on an annual basis. The Captain completed his last PAT in August 2011.

Preplacement and Annual Medical Evaluations. The FD requires preplacement medical evaluations for all applicants and annually for all members. Components of the medical evaluation include the following:

- Complete medical history
- Physical examination (including vital signs)
- Blood tests: complete blood count, lipid panel
- Urinalysis
- Urine drug screen (randomly for members)
- Spirometry
- Resting EKG
- Exercise stress test (preplacement and every five years)
- Hearing (audiometric) test
- Vision screen
- Baseline chest x-ray (preplacement and every five years)

Members receive a 12-lead exercise stress test every five years unless the annual resting EKG reveals an abnormality. Members also receive a chest x-ray every five years unless the annual tuberculosis skin rest is positive. The evaluations are performed by a city-contracted physician. Once this evaluation is completed, the physician makes a determination regarding medical clearance for fire fighting duties and forwards this decision to the city (for candidates) or the FD (for members). Medical clearance to wear a respirator and an annual self-contained breathing apparatus facepiece fit test are also required.

Members injured on duty are evaluated by the attending emergency department physician or the city-contracted physician. Members who are ill and miss four or more shifts must see a physician, who provides a medical clearance opinion to the city-contracted physician. For injuries and illnesses, the city-contracted physician makes the final determination regarding return to work.

Health and Wellness Programs. The FD has a voluntary wellness/fitness program but is working toward a mandatory program. Exercise equipment is available in all fire stations and at a City location.

Discussion

Atherosclerotic Coronary Heart Disease. In the United States, atherosclerotic CHD 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 CHD, smoking, high blood pressure, high blood cholesterol, obesity/physical inactivity, and diabetes [Greenland et al. 2010; NHLBI 2012; AHA 2013]. The Captain had four CHD risk factors (age older than 45, male gender, high blood pressure, high blood cholesterol).

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, an EKG did not reveal a heartbeat, cardiac enzymes were not tested, and no coronary artery thrombus was identified at autopsy. However, heart attacks can occur without a coronary thrombus [Davies 1992; Farb et al. 1995], and the Captain had microscopic evidence of plaque rupture in his left anterior descending coronary artery and severe atherosclerotic coronary disease identified at autopsy. Thus, a heart attack could have been responsible for the Captain's sudden death.

Primary Arrhythmia. A primary cardiac arrhythmia (e.g., ventricular tachycardia/fibrillation) could also have been responsible for the Captain's sudden cardiac death. Risk factors for arrhythmias include heart disease, heart attack, dietary supplements, smoking, alcohol, drug abuse, medications, diabetes, and hyperthyroidism [Mayo Clinic 2011; AHA 2012]. The Captain's CHD was revealed by his autopsy, which also reported borderline cardiomegaly, borderline left ventricular hypertrophy (discussed below), and severe atherosclerotic CHD, all conditions that increase the risk for primary arrhythmia. NIOSH investigators conclude that the Captain's sudden cardiac death was probably triggered by an arrhythmia, a heart attack, or his underlying CHD.

Cardiomegaly/Left Ventricular Hypertrophy. On autopsy, the Captain was found to have borderline left ventricular hypertrophy and a borderline enlarged heart (cardiomegaly). These conditions increase 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 hypertension, a heart valve problem, or chronic cardiac ischemia (reduced blood supply to the heart muscle) [Siegel 1997]. The Captain had hypertension but no heart valve problem was found at autopsy. Therefore, his left ventricular hypertrophy was probably related to chronic hypertension.

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 2013]. This voluntary industry standard provides the components of a preplacement and

Discussion (cont.)

annual medical evaluation and medical fitness for duty criteria. The Captain had two factors related to medical clearance: diabetes mellitus and coronary artery disease.

Diabetes Mellitus. NFPA 1582 provides guidance for fire department physicians to follow when treating diabetic fire fighters [NFPA 2013]. The standard states that fire fighters with diabetes mellitus that is controlled by diet, exercise, or oral hypoglycemic agents should be restricted from duty unless the member meets all of the following criteria:

(1) If on oral hypoglycemic agents, has had no episodes of severe hypoglycemia (defined as requiring assistance of another in the preceding year)
(2) Has achieved a stable blood glucose as evidenced by HA1C level less than 8 during the prior 3-month period
(3) Has a dilated retinal exam by a qualified ophthalmologist or optometrist that shows no higher grade of diabetic retinopathy than microaneurysms
(4) Has normal renal function on the basis of a calculated creatinine clearance greater than 60 milliliters per minute and absence of proteinuria
(5) Has no autonomic or peripheral neuropathy
(6) Has normal cardiac function without evidence of myocardial ischemia on cardiac stress testing (to at least 12 METs) by EKG and cardiac imaging [NFPA 2013].

The Captain's diabetes was being managed with oral medications. Assuming he had a dilated retinal exam, he met all six criteria.

Coronary Heart Disease. The Captain's CHD was not known until autopsy, therefore there was no reason to restrict his return to work on the basis of CHD. The Captain's angina episode on August 16, 2012, was explained by his forgetting to take his antihypertensive medication. However, he did not relate this incident to the City physician who cleared him on August 20, 2012, for return to work. On autopsy, the Captain was found to have severe CHD. Exercise stress tests can be used to screen for and identify occult CHD. However, 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.

NFPA 1582, a voluntary industry standard, recommends an exercise stress test performed "as clinically indicated by history or symptoms" and refers the reader to its Appendix A [NFPA 2013]. 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 (i.e., 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 (CAD)
- one 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 (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).

Discussion (cont.)

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 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 CAD 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 et al. 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% 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 CHD events. For individuals at increased risk for CHD 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."

Given the Captain's age and CHD risk profile (three known modifiable CHD risk factors), the NFPA, the ACC/AHA, and the Department of Transportation would have recommended a symptom limiting exercise stress test beginning after age 45. If a symptom limiting exercise stress was done earlier, perhaps his underlying CHD would have been identified and the Captain referred for further medical evaluation and treatment.

Recommendations

The following recommendations are offered to strengthen the FD's comprehensive safety and health program.

Recommendation #1: Incorporate exercise stress tests into the fire department medical evaluation program for fire fighters at increased risk for coronary heart disease.

NFPA 1582, the IAFF/IAFC Fire Service Joint Labor Management Wellness/Fitness Initiative, and the ACC/AHA recommend an exercise stress test for male fire fighters older than 45 with one or more coronary artery disease risk factors [IAFF, IAFC 2008; Gibbons et al. 2002; NFPA 2013b].

Recommendations (cont.)

The Captain was over the age of 45 and had three risk factors for CHD (high blood pressure, diabetes, and high cholesterol). Annual symptom-limiting exercise stress tests may have identified his underlying CAD.

Currently the FD does an exercise stress test on all applicants during their preplacement medical evaluation, regardless of the applicant's age, number of CHD risk factors, or severity of CHD risk factors. While this test has value to ensure the candidate has the aerobic capacity needed to be a fire fighter, its use on individuals at low risk for CHD is an unnecessary expense for the FD [Gibbons et al. 2002].

Recommendation #2: 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, and in Firefighter Fitness: A Health and Wellness Guide [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 [Chapman 2005; Mills et al. 2007; Pelletier 2009; Baicker et al. 2010]. Fire service health promotion programs have been shown to reduce CHD 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 a reduction of occupational injury/illness claims with additional savings expected from reduced future nonoccupational healthcare costs [Kuehl 2007]. The FD has a voluntary wellness/fitness program. NIOSH recommends a formal, mandatory wellness/fitness program to ensure all members receive the benefits of a health promotion program.

Recommendation #3: Discontinue exercise stress tests on asymptomatic young fire fighters with no risk factors for CHD.

Currently the FD does exercise stress test on all applicants during their preplacement medical evaluation and members during their annual medical evaluation, regardless of the number or severity of their CHD risk factors. While this test has value to ensure the candidate has the aerobic capacity needed to be a fire fighter, its use on individuals at low risk for CHD is an unnecessary expense. The American Heart Association/American College of Cardiology and NFPA 1582 recommend an exercise stress test only for people/fire fighters at increased risk for CHD defined as one or more coronary artery disease risk factors in male fire fighters over the age of 45 and female fire fighters over the age of 55 [Gibbons et al. 2002; NFPA 2013].

References

AHA [2012]. Understand your risk for arrhythmia. Dallas, TX: American Heart Association. [http://www.heart.org/HEARTORG/Conditions/Arrhythmia/UnderstandYourRiskforArrhythmia/Understand-Your-Risk-for-Arrhythmia_UCM_002024_Article.jsp]. Date accessed: February 2013.

AHA [2013]. Understand your risk of heart attack. Dallas, TX: American Heart Association. [http://www.heart.org/HEARTORG/Conditions/HeartAttack/UnderstandYourRiskofHeartAttack/Understand-Your-Risk-of-Heart-Attack_UCM_002040_Article.jsp]. Date accessed: February 2013.

Baicker K, Cutler D, Song Z [2010]. Workplace Wellness Programs Can Generate Savings. Health Affairs *29*(2):1-8.

Blevins JS, Bounds R, Armstrong E, Coast JR [2006]. Health and fitness programming for fire fighters: does it produce results? Med Sci Sports Exerc *38*(5):S454.

Blumenthal RS, Epstein AE, Kerber RE [2007]. Expert panel recommendations. Cardiovascular disease and commercial motor vehicle driver safety. [http://www.mrb.fmcsa.dot.gov/documents/CVD_Commentary.pdf]. Date accessed: February 2013.

CDC (Centers for Disease Control and Prevention) [2011]. BMI – Body Mass Index. [http://www.cdc.gov/healthyweight/assessing/bmi/index]. Date accessed: February 2013.

Chapman LS [2005]. Meta-evaluation of worksite health promotion economic return studies: 2005 update. Am Health Promot *19*(6):1–11.

Davies MJ [1992]. Anatomic features in victims of sudden coronary death. Coronary artery pathology. Circulation 85[Suppl I]:I-19–24.

Dempsey WL, Stevens SR, Snell CR [2002]. Changes in physical performance and medical measures following a mandatory firefighter wellness program. Med Sci Sports Exerc *34*(5):S258.

Farb A, Tang AL, Burke AP, Sessums L, Liang Y, Virmani R [1995]. Sudden coronary death: frequency of active lesions, inactive coronary lesions, and myocardial infarction. Circulation *92*(7):1701–1709.

Fuster V, Badimon L, Badimon JJ, Chesebro JH [1992]. The pathogenesis of coronary artery disease and the acute coronary syndromes. N Engl J Med *326*(4):242–250.

Gibbons RJ, Balady GJ, Bricker JT, Chaitman BR, Fletcher GF, Froelicher VF, Mark DB, McCallister BD, Mooss AN, O'Reilly MG, Winters WL Jr., Antman EM, Alpert JS, Faxon DP, Fuster V, Gregoratos G, Hiratzka LF, Jacobs AK, Russell RO, Smith SC Jr. [2002]. ACC/AHA 2002 guideline update for exercise testing: a report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines. Circulation *106*(14):1883–1892.

Greenland P, Alpert JS, Beller GA, Benjamin EJ, Budoff MJ, Fayad ZA, Foster E, Hlatky MA, Hodgson JM, Kushner FG, Lauer MS, Shaw LJ, Smith SC Jr., Taylor AJ, Weintraub WS, Wenger NK [2010]. 2010 ACCF/AHA guideline for assessment of cardiovascular risk in asymptomatic adults: a report of the American College of Cardiology Foundation/American Heart Association Task Force on Practice Guidelines. Circulation *122*(25):e584–e636.

IAFF, IAFC [2008]. The fire service joint labor management wellness/fitness initiative. 3rd ed. Washington, DC: International Association of Fire Fighters, International Association of Fire Chiefs.

References (cont.)

Kuehl K [2007]. Economic impact of the wellness fitness initiative. Presentation at the 2007 John P. Redmond Symposium in Chicago, IL on October 23, 2007.

Levy D, Garrison RJ, Savage DD, Kannel WB, Castelli WP [1990]. Prognostic implications of echocardiographically determined left ventricular mass in the Framingham Heart Study. N Engl J Med *323*(24):1706–1707.

Libby P [2008]. The pathogenesis, prevention, and treatment of atherosclerosis. In: Fauci AS, Braunwald E, Kasper DL, Hauser SL, Longo DL, Jameson JL, Loscalzo J, eds. Harrison's principles of internal medicine. 17th ed. New York: McGraw-Hill, pp. 1501–1509.

Mayo Clinic [2011]. Heart arrhythmias. [http://www.mayoclinic.com/health/heart-arrhythmias/DS00290/METHOD=print&DSECTION=all]. Date accessed: February 2013.

Meyerburg RJ, Castellanos A [2008]. Cardiovascular collapse, cardiac arrest, and sudden cardiac death. In: Fauci AS, Braunwald E, Kasper DL, Hauser SL, Longo DL, Jameson JL, Loscalzo J, eds. Harrison's principles of internal medicine. 17th ed. New York: McGraw-Hill, pp. 1707–1713.

Mills PR, Kessler RC, Cooper J, Sullivan S [2007]. Impact of a health promotion program on employee health risks and work productivity. Am J Health Promot *22*(1):45–53.

NFPA [2008]. Standard on health-related fitness programs for fire fighters. Quincy, MA: National Fire Protection Association. NFPA 1583.

NFPA [2013]. Standard on comprehensive occupational medical program for fire departments. Quincy, MA: National Fire Protection Association. NFPA 1582.

NHLBI [2012]. Who is at risk for coronary artery disease? National Heart, Lung, and Blood Institute. [http://www.nhlbi.nih.gov/health/health-topics/topics/cad/atrisk.html]. Date accessed: February 2013.

Pelletier KR [2009]. A review and analysis of the clinical and cost–effectiveness studies of comprehensive health promotion and disease management programs at the worksite: update VII 2004–2008. J Occup Environ Med *51*(7):822–837.

Schneider EL [2010]. Firefighter fitness: a health and wellness guide. New York: Nova Science Publishers.

Shah PK [1997]. Plaque disruption and coronary thrombosis: new insight into pathogenesis and prevention. Clin Cardiol *20*(11 Suppl2):II-38–44.

Siegel RJ [1997]. Myocardial hypertrophy. In: Bloom S, ed. Diagnostic criteria for cardiovascular pathology acquired diseases. Philadelphia, PA: Lippencott-Raven, pp. 55–57.

USPSTF [2004]. U.S. Prevention Services Task Force. Screening for coronary heart disease: Recommendation Statement. Ann Intern Med *140*(7):569–572.

Womack JW, Humbarger CD, Green JS, Crouse SF [2005]. Coronary artery disease risk factors in firefighters: effectiveness of a one-year voluntary health and wellness program. Med Sci Sports Exerc *37*(5):S385.

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 Health, and Vice-Chair of the Public Safety Medicine Section of the American College of Occupational and Environmental Medicine (ACOEM).

Appendix A

Autopsy Findings

- Hypertensive heart disease
  - Borderline cardiomegaly (enlarged heart; heart weighed 409 grams [g]; predicted normal weight is 331 g [ranges between 251 g and 437 g as a function of sex, age, and body weight]) [Silver and Silver 2001]
  - Concentric left ventricular hypertrophy
    - Left ventricle and interventricular septum thickened (1.0 centimeter [cm] each)
      - Normal at autopsy is 0.76–0.88 cm [Colucci and Braunwald 1997]
      - Normal by echocardiographic measurement is 0.6–1.0 cm [Connolly and Oh 2012]
  - Microscopic: areas of fibrosis between myofibers and severe atherosclerosis with some plaque hemorrhage
- Coronary artery atherosclerosis
  - Severe (90%) focal narrowing of the circumflex coronary artery coronary artery
  - Severe (90%) focal narrowing of the right coronary artery
  - Severe (80%) focal narrowing of the left anterior descending coronary artery, with a possible plaque hemorrhage in the middle third
  - No definitive coronary artery thrombus (blood clot)
- Normal cardiac valves
- No evidence of a pulmonary embolus (blood clot in the lung arteries)
- Blood tests for drugs and alcohol were negative.

References

Colucci WS, Braunwald E [1997]. Pathophysiology of heart failure. In: Braunwald, ed. Heart disease. 5th ed. Philadelphia, PA: W.B. Saunders Company, p. 401.

Connolly HM, Oh JK [2012]. Echocardiography. In: Bonow RO, Mann DL, Zipes DP, Libby P, Braunwald E, eds. Heart disease: a text of cardiovascular medicine. 9th ed. Vol. 1. Philadelphia, PA: Elsevier Saunders, p. 216.

Silver MM, Silver MD [2001]. Examination of the heart and of cardiovascular specimens in surgical pathology. In: Silver MD, Gotlieb AI, Schoen FJ, eds. Cardiovascular pathology. 3rd ed. Philadelphia, PA: Churchill Livingstone, pp. 8–9.