2012
05

Death in the line of duty...

NIOSH
Fire Fighter Fatality Investigation and Prevention Program

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

Wildland Fire Fighter Trainee Suffers Sudden Cardiac Death During Physical Fitness Exercise – California

Executive Summary

In 2011, a 54-year old State inmate was accepted into the State's "Conservation Camps" program which trains inmates for wildland fire suppression. On January 4, 2012, the trainee was participating in a physical fitness exercise which involved hiking in moderately steep terrain while wearing wildland personal protective equipment (PPE) and carrying handtools. The PPE and the tools weighed approximately 18 pounds. As the Trainee completed the exercise, the crew leader determined he needed medical attention and called for an ambulance. While awaiting an ambulance, the Trainee's condition deteriorated and he became unresponsive. Cardiopulmonary resuscitation (CPR) was begun and 15 minutes later an automated external defibrillator (AED) from the responding engine arrived and advised no shock. Approximately 3 minutes later, the ambulance with paramedics arrived and provided advanced life support (ALS). Despite CPR and ALS in the ambulance and in the local hospital's emergency department (ED), the Trainee died.

The autopsy report listed "acute myocardial infarction due to atherosclerotic coronary artery disease" as the cause of death. Given the Trainee's underlying cardiovascular disease, NIOSH investigators concluded that the physical stress of physical fitness training probably triggered his sudden cardiac death.

NIOSH investigators offer the following recommendations to address general safety and health issues and to prevent future similar events.

Provide preplacement and annual medical evaluations to all fire fighters consistent with NFPA 1582, Standard on Comprehensive Occupational Medical Program for Fire Departments, and NFPA 1051, Standard for Wildland Fire Fighter Professional Qualifications.

Make basic life support equipment, including an AED, readily available during strenuous training exercises.

Provide fire fighters with medical clearance to wear a respirator as part of the Fire Department's medical evaluation program.

Provide annual respirator fit testing for fire fighters who wear respirators.

Introduction & Methods

On January 4, 2012, a 54-year-old male wildland fire fighter trainee collapsed during physical fitness training and died. NIOSH contacted the affected agency (State Department of Corrections) on January 12, 2012, to gather information, and again on February 15, 2012, to initiate the investigation. On March 1, 2012, a safety and occupational health specialist from the NIOSH Fire Fighter Fatality Prevention and Investigation Program conducted an on-site investigation of the incident.

Wildland Fire Fighter Trainee Suffers Sudden Cardiac Death During Physical Fitness Exercise – California

Wildland Fire Fighter Trainee Suffers Sudden Cardiac Death During Physical Fitness Exercise – California

Introduction & Methods (cont.)

During the investigation, NIOSH personnel interviewed the following people:

- Fire Chief
- Correctional Officers Crew members

NIOSH personnel reviewed the following documents:

- FD standard operating procedures
- Facility incident reports
- Emergency medical service (ambulance) report
- Hospital's ED report
- Autopsy
- Correctional facility physician records

Investigative Results

Incident. On January 4, 2012, the Trainee began his first day of wildland fire fighter training. Fifteen trainees participated in the training which included hiking in terrain with a 14-degree slope (511 feet of elevation in 0.7 miles). The training program was one of 42 throughout California training State inmates to become wildland fire fighters. It is administered by the State's Department of Corrections (the Agency) and the State's Division of Forestry. In addition to fighting wildland fires, trained personnel respond to other emergencies such as floods and earthquakes, and assist with conservation projects. Approximately 4,000 inmates participate in the program on approximately 200 fire crews.

The morning of January 4, 2012 was spent on classroom and orientation training. At approximately 1520 hours, the Trainee, other trainees, and the State forestry fire captain began the physical fitness hike. All wore full wildland PPE including Nomex® pants, Nomex® top, helmet, gloves, fire pack with integrated hydration reservoir (weighing approximately 10 pounds), and canteens. The crew also carried hand tools such as an axe or forestry rake which weighed about 5–8 pounds.

Investigative Results (cont.)

Throughout the hike, the Trainee did not report any symptoms or exhibit any signs of a medical problem. As the Trainee reached the top of the hill (approximately 1540 hours), he became short of breath and began crawling on his hands and knees near the finish point. The Captain observed the Trainee, determined he needed medical attention, and tried unsuccessfully (due to an insufficient radio signal) to contact the local emergency command center. He successfully reached the command center by cell phone at 1544 hours and requested an ambulance. While the Captain was on the phone with the command center, the Trainee suddenly became unresponsive with no pulse and no respirations. Crew members began CPR.

The dispatch/command center notified the ambulance service at 1545 hours, and Medic 52 responded at 1548 hours. Meanwhile, Engine 5188 from the correctional facility's fire department was dispatched via mutual aid. Engine 5188 arrived at the scene at 1559 hours to find the Trainee unresponsive, with no pulse or respirations, and with CPR in progress. An AED was attached to the Trainee, and no shock was advised. An oropharyngeal airway was inserted and oxygen was administered via bag-valve-mask.

Medic 52 arrived at 1602 hours and began ALS including intubation and intravenous line placement. Tube placement was verified by capnography [Neumar et al. 2010]. The Trainee was placed into the ambulance which departed the scene en route to the hospital's ED at 1619 hours.

Wildland Fire Fighter Trainee Suffers Sudden Cardiac Death During Physical Fitness Exercise – California

Investigative Results (cont.)

Medic 52 arrived at the ED at 1630 hours, approximately 45 minutes after the Trainee's collapse. Inside the ED, resuscitation efforts continued until 1642 hours when the attending physician pronounced the Trainee dead.

Medical Findings. The autopsy report, completed by the county pathologist, listed "acute myocardial infarction due to atherosclerotic coronary artery disease" as the cause of death. Findings from the autopsy are listed in Appendix A.

The Trainee was 70 inches tall and weighed 199 pounds, giving him a body mass index of 28.6 kilograms per meters squared. A BMI of 25.0 – 29.9 kg/m2 is considered overweight [CDC 2011]. The Trainee's risk factors for coronary artery disease included hypertension (high blood pressure) diagnosed prior to 2010 and hypercholesterolemia (high blood cholesterol) diagnosed in 2011. He was prescribed diet modification, exercise, and medications. Although a blood pressure-lowering medication and a cholesterol-lowering medication were prescribed, the Trainee did not fill the prescriptions. The Trainee never complained about cardiac symptoms and participated in the Agency's 4-week wellness/fitness program (described below). During his preplacement medical evaluation in September 2011, the Trainee was cleared for vigorous firefighting duties.

Description of the Facility

At the time of the NIOSH investigation, the correctional facility maintained 12 structural fire fighters (1 fire station) and 108 wildland fire fighters; all were inmates. Additional trained inmates staffed a mobile kitchen which deployed to emergency incidents. The structural fire fighters provide fire and emergency medical response to the correctional facility which includes three structures with 1.2 million square feet housing approximately 5,700 inmates. The 108 wildland fire fighters service a 6-square mile area.

Membership and Training. The State Agency requires new inmate fire fighter applicants to pass a medical evaluation (discussed below), a candidate physical ability test (discussed below), and an interview. Structural fire fighter trainees are assigned to the FD to begin First Responder and Fire Fighter 1 and 2 training provided the inmate is not schedule for release prior to completing these programs.

Medical Evaluations. The Agency requires preplacement medical evaluations for all fire fighter applicants and annual evaluations for members. Components of the medical evaluation include the following:

- Complete medical history
- Physical examination (including vital signs)
- Blood tests: complete blood count, lipid panel

The evaluations are performed by an Agency physician. Once an evaluation is completed, the physician makes a determination regarding medical clearance for fire fighting duties and forwards this decision to the FD. It is unclear if this medical clearance also clears the applicant

Wildland Fire Fighter Trainee Suffers Sudden Cardiac Death During Physical Fitness Exercise – California

Description of the Facility (cont.)

to wear a respirator. An annual SCBA facepiece fit test is not required.

Fitness Program and Physical Ability Test. All fire fighter candidates and members must participate in the 4-week physical fitness program. Exercise equipment is provided in the fire station and training areas. At the end of the program, candidates must pass two physical ability tests, including a gym test (Appendix B), and a hill climb. The hill climbinvolved climbing a 0.7-mile hill with a 14-degree slope.

The Trainee had participated in the 4-week physical fitness program by running, circuit training (squats, burpees, push-ups, mountain climbers, chair dips, toe-ups, jump rope, jumping jacks, Harvard steps, and plyometrics), obstacle jump, abdominal workout, exercise band, medicine ball, and ankle weights. He also passed the gym portion of his physical fitness test. He was training for the hill climb when he suffered his sudden cardiac death. He had no prior fire fighting experience.

Other Medical Evaluations. Members injured on duty are evaluated by the Agency physician. The physician determines the functional capacity level (vigorous duty, full duty, limited duty, totally disabled) and forwards their medical clearance opinion to the Agency. Members who are ill and miss two or more shifts must provide a medical clearance statement from the Agency physician.

Discussion

Atherosclerotic Coronary Heart Disease (CHD). 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 [NHLBI 2011; AHA 2012a]. The Trainee had four CHD risk factors (age older than 45, male gender, high blood pressure, and 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 was not performed because the Trainee had no heart beat, cardiac enzymes were not tested, and no coronary artery thrombus was identified at autopsy. However, heart attacks can occur without evidence of a coronary thrombus [Davies 1992; Farb et al. 1995]. Thus, although not confirmed, a heart attack was probably responsible for the Trainee's sudden death and was listed as the cause of death on the death certificate and autopsy report.

Wildland Fire Fighter Trainee Suffers Sudden Cardiac Death During Physical Fitness Exercise – California

Discussion (cont.)

Epidemiologic studies have found that heavy physical exertion sometimes immediately precedes and triggers the onset of acute heart attacks and sudden cardiac death [Mittleman et al. 1993; Willich et al. 1993; Albert et al. 2000]. Heart attacks in fire fighters have been associated with alarm response, fire suppression, and heavy exertion during training (including physical fitness training) [Kales et al. 2003; Kales et al. 2007; NIOSH 2007]. The Trainee had performed physical fitness training by hiking up a 14% slope, 511feet of elevation within 0.7 miles with about 18 pounds of gear. This activity expended about 8 metabolic equivalents (METs), which is considered moderate physical activity [AIHA 1971; Ainsworth et al. 2011]. NIOSH investigators conclude that the Trainee's sudden cardiac death was probably an acute myocardial infarction triggered by his physical activity in conjunction with his underlying CHD.

Primary Arrhythmia. A primary cardiac arrhythmia (e.g., ventricular tachycardia/fibrillation) could have also been responsible for the Trainee'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 2012b]. Although the Trainee did not have known heart disease prior to his death, his autopsy confirmed moderate CHD and cardiomegaly (discussed below). These conditions increase the risk for a primary arrhythmia and sudden cardiac death [Levy 1990].

Occupational Medical Standards for Wildland Fire Fighters. NFPA 1051, Standard for Wildland Fire Fighter Professional Qualifications, sets forth the requirements to become a wildland fire fighter including physical fitness and medical considerations. For medical clearance, NFPA 1051 refers to NFPA 1582, Standard on Comprehensive Occupational Medical Program for Fire Departments [NFPA 2007a; NFPA 2007b].

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 2007b]. This voluntary industry standard provides the components of a preplacement and annual medical evaluation and medical fitness for duty criteria. The Trainee did not have any known medical conditions that would have required restrictions. However, he did have CHD risk factors, which in consideration of the Trainee's age, should have triggered an exercise stress test [NFPA 2007b] (see next section).

Exercise Stress Tests. Guidance regarding testing asymptomatic individuals without known heart disease with exercise stress tests is varied. The following paragraphs summarize the positions of widely recognized organizations on this topic.

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

Discussion (cont.)

following conditions:

- abnormal screening submaximal tests
- cardiac symptoms
- known coronary artery disease
- two or more risk factors for coronary artery disease (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 coronary artery disease (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 is "less well established" (Class IIb) for the following groups:

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

The U.S. Department of Transportation provides guidance for those seeking medical certification for a commercial driver's license. An expert medical panel recommended exercise tolerance tests (stress tests) for asymptomatic high risk drivers [Blumenthal 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 coronary heart disease
- Framingham risk score predicting a 20% coronary heart disease event risk over the next 10 years

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

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

Recommendations

NIOSH investigators offer the following recommendations to address general safety and health issues and to prevent future similar events.

Recommendation #1: Provide preplacement and annual medical evaluations to all fire fighters consistent with NFPA 1582, Standard on Comprehensive Occupational Medical Program for Fire Departments, and NFPA 1051, Standard for Wildland Fire Fighter Professional Qualifications.

Guidance regarding the content and frequency of these medical evaluations can be found in NFPA 1582 [NFPA 2007b]. While the Agency conducts preplacement and annual medical evaluations, these evaluations do not include exercise stress tests for candidates/members at risk for CHD. NIOSH investigators recommend the Agency conduct exercise stress tests for fire fighters at increased risk for coronary heart disease based on the NFPA and the ACC/AHA guidelines [Gibbons et al. 2002; NFPA 2007b]. Although NIOSH recommends following these guidelines, the Agency is not legally required to follow them.

Recommendation #2: Make basic life support equipment, including an AED, readily available during strenuous training exercises.

Preservation of human life is the primary responsibility of the fire department during fires and other emergencies. Most of the sudden cardiac deaths in the United States result from ventricular fibrillation. The chain of survival from cardiac arrest includes: (1) immediate recognition of cardiac arrest and activation of the emergency response system, (2) early CPR with an emphasis on chest compressions, (3) rapid defibrillation, (4) effective advanced life support, and (5) integrated post-cardiac arrest care [AHA 2011]. Rapid defibrillation using AEDs has increased the cardiac arrest survival rate from 6.7% (CPR performed only) to 34% [Sasson et al. 2010; Weisfeldt et al. 2011]. When defibrillation is provided within 3–5 minutes, the survival rate is as high as 74% [Link et al. 2010]. The FD engine had an AED, but it was 15 minutes away. The Trainee's chances of surviving cardiac arrest would have increased if an AED was readily available and an AED-trained responder was nearby [Marenco et al. 2001; Koster 2002].

Recommendation #3: Provide fire fighters with medical clearance to wear a respirator as part of the Fire Department's medical evaluation program.

The Occupational Safety and Health Administration (OSHA) Revised Respiratory Protection Standard requires employers to provide medical evaluations and clearance for employees using respiratory protection [29 CFR 1910.134]. These clearance evaluations are required for private industry employees and public employees in states operating OSHA-approved state plans. California operates an OSHA-approved state plan; therefore the Agency is required to ensure all structural fire fighters have been medically cleared to wear a respirator.

Recommendation #4: Provide annual respirator fit testing for fire fighters who wear respirators.

The Occupational Safety and Health Administration (OSHA) Revised Respiratory Protection Standard requires that, before an employee may be required to use any respirator with a negative

Recommendations (cont.)

or positive pressure tight-fitting facepiece, the employee must be fit tested with the same make, model, style, and size of respirator that will be used [29 CFR 1910.134]. Because California operates an OSHA-approved state plan, the Agency is required to ensure all fire fighters have been fit tested to wear an SCBA or tight fitting respirator.

References

AHA [2011]. Chain of survival. Dallas, TX: American Heart Association. [http://www.heart.org/HEARTORG/CPRAndECC/WhatisCPR/ECCIntro/Chain-of-Survival_UCM_307516_Article.jsp]. Date accessed: August 2012.

AHA [2012a]. 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: August 2012.

AHA [2012b]. 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: August 2012.

AIHA [1971]. Ergonomics guide to assessment of metabolic and cardiac costs of physical work. Am Ind Hyg Assoc J *32*(8):560–564.

Ainsworth BE, Haskell WL, Herrmann SD, Meckes N, Bassett DR Jr, Tudor-Locke C, Greer JL, Vezina J, Whitt-Glover MC, Leon AS [2011]. Compendium of physical activities: a second update of codes and MET values. Med Sci Sports Exerc *43*(8):1575–1581.

Albert CM, Mittleman MA, Chae CU, Lee IM, Hennekens CH, Manson JE [2000]. Triggering of sudden death from cardiac causes by vigorous exertion. N Engl J Med *343*(19):1355–1361.

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: August 2012.

CDC (Centers for Disease Control and Prevention) [2011]. BMI – Body Mass Index. [http://www.cdc.gov/healthyweight/assessing/bmi/index]. Date accessed: August 2012.

CFR. Code of Federal Regulations. Washington, DC: U.S. Government Printing Office, Office of the Federal Register.

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

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.

References (cont.)

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.

Kales SN, Soteriades ES, Christoudias SG, Christiani DC [2003]. Firefighters and on-duty deaths from coronary heart disease: a case control study. Environ health: a global access science source. 2:14. [http://www.ehjournal.net/content/2/1/14]. Date accessed: July 2012.

Kales SN, Soteriades ES, Christophi CA, Christiani DC [2007]. Emergency duties and deaths from heart disease among fire fighters in the United States. N Engl J Med *356*(12):1207–1215.

Koster RW [2002]. Automatic external defibrillator: key link in the chain of survival. J Cardiovasc Electrophysiol *13*(1 Suppl):S92-95.

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.

Link MS, Atkins DL, Passman RS, Halperin HR, Samson RA, White RD, Cudnik MT, Berg MD, Kudenchuk PJ, Kerber RE [2010]. Part 6: Electrical therapies: automated external defibrillators, defibrillation, cardioversion, and pacing. 2010 American Heart Association Guidelines for cardiopulmonary resuscitation and emergency cardiovascular care. Dallas, TX: American Heart Association. [http://circ.ahajournals.org/content/122/18_suppl_3/S706.full.pdf+html]. Date accessed: August 2012.

Marenco JP, Wang PJ, Link MS, Homoud MK, Estes NA 3rd [2001]. Improving survival from sudden cardiac arrest: the role of the automated external defibrillator. JAMA *285*(9):1193-1200.

Mayo Clinic [2011]. Heart arrhythmias. [http://www.mayoclinic.com/health/heart-arrhythmias/DS00290/METHOD=print&DSECTION=all]. Date accessed: August 2012.

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.

References (cont.)

Mittleman MA, Maclure M, Tofler GH, Sherwood JB, Goldberg RJ, Muller JE [1993]. Triggering of acute myocardial infarction by heavy physical exertion. N Engl J Med *329*(23):1677–1683.

NFPA [2007a]. Standard for wildland fire fighter professional qualifications. Quincy, MA: National Fire Protection Association. NFPA 1051.

NFPA [2007b]. Standard on comprehensive occupational medical program for fire departments. Quincy, MA: National Fire Protection Association. NFPA 1582.

NHLBI [2011]. 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: August 2012.

NIOSH [2007]. NIOSH alert: preventing fire fighter fatalities due to heart attacks and other sudden cardiovascular events. [http://www.cdc.gov/niosh/docs/2007-133/]. Cincinnati, OH: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, DHHS (NIOSH) Publication No. 2007-133.

Neumar RW, Otto CW, Link MS, Kronick SL, Shuster M, Callaway CW, Kudenchuk PJ, Ornato JP, McNally B, Silvers SM, Passman RS, White RD, Hess EP, Tang W, Davis D, Sinz E, Morrison LJ [2010]. Part 8: Adult advanced cardiovascular life support. 2010 American Heart Association Guidelines for cardiopulmonary resuscitation and emergency cardiovascular care. Dallas, TX: American Heart Association. [http://circ.ahajournals.org/content/122/16_suppl_2/S345.full.pdf+html]. Date accessed: August 2012.

Sasson C, Rogers MAM, Dahl J, Kellermann AL [2010]. Predictors of survival from out-of-hospital cardiac arrest, a systematic review and meta-analysis. Circ Cardiovasc Qual Outcomes *3*(1):63-81.

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

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

Weisfeldt ML, Everson-Stewart S, Sitlani C, Rea T, Aufderheide TP, Atkins DL, Bigham B, Brooks SC, Foerster C, Gray R, Ornato JP, Powell J, Kudenchuk PJ, Morrison LJ [2011]. Ventricular tachyarrhythmias after cardiac arrest in public versus at home. N Engl J Med *364*(4):313-321.

Willich SN, Lewis M, Lowel H, Arntz HR, Schubert F, Schroder R [1993]. Physical exertion as a trigger of acute myocardial infarction. N Engl J Med *329*(23):1684–1690.

Wildland Fire Fighter Trainee Suffers Sudden Cardiac Death During Physical Fitness Exercise – California

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

- Coronary artery atherosclerosis
  - Moderate to severe (70%) focal narrowing of the left anterior descending coronary artery
  - Cardiomegaly (enlarged heart; heart weighed 500 grams [g]; predicted normal weight is 371 g [ranges between 281 g and 489 g as a function of sex, age, and body weight]) [Silver and Silver 2001]
- Normal cardiac valves
- No evidence of a coronary artery thrombus (blood clot)
- No evidence of a pulmonary embolus (blood clot in the lung arteries)
- Blood tests for drugs and alcohol were negative

Reference

Silver MM and 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.

Wildland Fire Fighter Trainee Suffers Sudden Cardiac Death During Physical Fitness Exercise – California

Appendix B

Physical Ability (Gym) Test

- Set One includes push ups, chair dips, Ab crunches, and toe ups for 1 minute each
- Set Two includes side situps (1 minute each side), knee up crunches, push ups, and burpees (squat thrust) for 2 minutes each
- Set Three includes flutter kick, push ups, mountain climbers, and bench crunches for 2.5 minutes each
- Harvard steps (the subject steps up and down on a platform at a height of about 45 cm. at a rate of 30 steps per minute) for 1 minute each leg
- Harvard steps for 2 minutes each leg
- Harvard steps for 3 minutes each leg