2011
27

Death in the line of duty...

NIOSH
Fire Fighter Fatality Investigation and Prevention Program

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

Fire Fighter Suffers Cardiac Death After Responding to a Structure Fire – New York

Executive Summary

On May 18, 2011, a 43-year-old male volunteer fire fighter (FF) suffered a cardiac event en route to a structure fire. While riding in the cab of the apparatus, the FF complained of chest pains. Upon arrival at the fire scene 3 or 4 minutes later, crew members assisted the FF and notified the on-site Emergency Medical Service (EMS) personnel. EMS personnel assessed the FF, administrated cardiac drugs, and transported the FF to a nearby hospital. Approximately 30 minutes after arrival at the emergency department (ED), the FF had a cardiac arrest. Advanced cardiac life support (ACLS) measures, including intubation and defibrillation (shock), were performed. Despite these efforts, the FF died. The death certificate listed the immediate cause of death as "atherosclerotic and hypertensive cardiovascular disease." The autopsy revealed cardiomegaly (enlarged heart), left ventricular hypertrophy (LVH), severe coronary artery disease (CAD), and myocardial scarring consistent with a previous (old) heart attack. Given the FF's underlying coronary heart disease, the adrenaline rush of responding to the alarm and running about 400 hundred yards to the fire house may have triggered a heart attack.

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 exercise stress tests on FFs at risk for sudden cardiac events.

Perform an annual physical performance (physical ability) evaluation.

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

Introduction & Methods

On May 18, 2011, a 43 year-old volunteer FF complained of chest pain while en route to a structure fire. Fellow fire fighters initiated immediate care and called EMS who transported the FF to a nearby hospital. Shortly after arriving at the ED, the FF suffered a cardiac arrest; subsequent resuscitation efforts were unsuccessful. NIOSH was notified of this fatality on May 18, 2011, by the U.S. Fire Administration. NIOSH contacted the affected FD on May 20, 2011, to obtain additional information and again on December 14, 2011, to request further information and schedule the investigation. On January 23, 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:

- District Supervisor
- Fire Chief
- Crew member working with the FF
- EMS personnel who treated the FF
- FF's brother (also a fire fighter)
- FF's FD physician

Fire Fighter Suffers Cardiac Death After Responding to a Structure Fire – New York

Fire Fighter Suffers Cardiac Death After Responding to a Structure Fire – New York

Introduction & Methods (cont.)

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

- FD records
- FD general operating procedures
- FD incident report
- Witness statements taken shortly after the incident
- Ambulance prehospital care report
- Death certificate
- Medical examiner's report
- Hospital records
- Personal physician medical records
- FD medical records

Investigative Results

Incident. On May 18, 2011, at approximately 0337 hours, the FD received an alarm for a structure fire. The FF received the call at his apartment located about 400 yards from the fire house and ran to the station. The first FD apparatus left the station at 0344 hours with the FF on board. En route the FF complained of chest pains and fellow fire fighters riding in the cab with him noticed that he was in distress. As the engine arrived on scene (0348 hours), the driver passed their assigned hydrant and a fire fighter in the cab called for another fire fighter to bring oxygen. Crew members helped the FF out of the cab and placed him on oxygen.

Crew members notified personnel already at the scene and an emergency medical technician (EMT) was directed to the FF. The EMT found the FF sitting on the step of the Engine wearing his bunker coat and pants and his helmet. The FF was pale and diaphoretic (sweating heavily); he was leaning forward and bracing himself on his knees. The FD ambulance pulled up to the Engine within 30 seconds of the first EMT arriving. The FF was placed on a stretcher and loaded into the ambulance. The FF was complaining of severe chest pain and that he could not breathe. Vital signs showed a respiratory rate of 36 breaths per minute (normal 8-12), a heart rate of 36 beats per minute (bpm) (normal 60-100), and blood pressure of 117/103 millimeters of mercury (mmHg) (normal 80-120/60-90). A four lead electrocardiogram (EKG) for the Lifepac® monitor was performed, indicating that the FF had sinus bradycardia (slow heart rhythm). In addition to the oxygen, an intravenous line was established and the FF was provided fluid, atropine, and aspirin. The ambulance departed the scene at 0402 hours.

Investigative Results (cont.)

The ambulance arrived at the ED at 0408 hours. Initial assessment by the triage unit revealed the FF was alert and oriented; he had a pulse of 39 bpm, a respiration rate of 26 breaths per minute, and oxygen saturation at 100%. On a 1 to 10 scale, the FF rated his chest pain level as 10. The attending physician was consulted and medications consistent with treatment for an acute heart attack (nitroglycerin, Plavix®, and heparin) were ordered. The EKG revealed ST changes consistent with an acute myocardial infarction (heart attack). At 0435 hours, just after the FF was transported to a room and before medications could be administered, the FF went into cardiac arrest.

The FF was intubated with an oral endotracheal tube (with placement confirmed by capnometry). The FF's heart rhythm had degenerated into ventricular fibrillation for which two defibrillation attempts (shocks) were made. This changed his heart rhythm to asystole (no heart beat). The FF received cardiac drugs (epinephrine, atropine, bicarbonate) per ACLS protocols and CPR continued until 0501 hours, when he was pronounced dead and resuscitation efforts were stopped.

Fire Fighter Suffers Cardiac Death After Responding to a Structure Fire – New York

Investigative Results (cont.)

Medical Findings. The death certificate, completed by the Deputy Medical Examiner for the County, listed the immediate cause of death as "atherosclerotic and hypertensive cardiovascular disease." The autopsy, also conducted by the Deputy Medical Examiner, revealed cardiomegaly, LVH, severe CAD, and myocardial scarring consistent with a previous (old) heart attack. See Appendix A for a more complete description of pertinent autopsy findings.

The FF had a history of hypertension managed by his primary care physician. The FF was first diagnosed with hypertension in 2007 (office blood pressure of 180/120 mmHg with repeat measurement of 170/100 mmHg). Further evaluation included an echocardiogram which revealed mild LVH (left ventricular wall thickness = 1.2 centimeters (cm) (normal 0.6 to 1.0 cm) and a normal ejection fraction [Connolly and Oh 2012]. The FF's blood pressure was under fair control with medication from 2007 to 2009, but in 2010, the FF reported that he had run out of his prescription and had not taken his blood pressure medication for over 1 year. In March 2011, the FF's blood pressure was 160/110 mmHg and he was prescribed a new medication. On April 30, 2011, less than 3 weeks before his fatal event, the FF was rechecked in the physician's office and his blood pressure was 120/80 mmHg. The physician records indicate that the FF needed an EKG but there is no evidence that this was done.

The FF worked as a driver and delivery person, and thus engaged in a moderate level of manual labor. He played recreational softball, but did not engage in regular exercise. The FF was 70 inches tall and weighed 289 pounds, giving him a body mass index (BMI) of 41.5 kilograms per meter squared. A BMI of greater than or equal to 30.0 kilograms per meter squared is considered obese [CDC 2011]. The FF's risk factors for CAD included family history, hypertension, smoking, obesity, and lack of regular exercise.

Description of the Fire Department

The FD has approximately 210 members, organized into seven fire companies operating from four fire stations. The FD serves a population of approximately 45,000 in an area of approximately 5 square miles. The FD responded to over 2,100 calls in 2011 (including over 800 fire calls).

Membership. Potential members must be at least 19 years old and complete an application package, which is reviewed by a membership committee. Applicants must pass a background check, a preplacement medical evaluation (described below), and an interview with the membership committee. The membership committee then introduces the applicant to the fire company and the FD for action.

Training. The FD requires members to regularly attend departmental training. The FD provides live fire training for its members once per year. The FF had taken several training classes and had been voted by his company to serve as Captain (for a 1- year rotation). At the time of his death, the ex-Captain was serving in the rank of fire fighter. He had 21 years of firefighting experience.

Preplacement and Periodic Medical Evaluations. The FD requires preplacement medical evaluations for all applicants and annual medical evaluations for all members. These evaluations are conducted by an occupational medicine clinic

Description of the FD (cont.)

under contract to the department. The evaluations include the following components:

- Health history
- Blood pressure check
- Physical examination
- Blood tests
- Spirometry
- Resting EKG
- Hearing test
- Vision test

Medical clearance for use of a self-contained breathing apparatus is required by the FD annually. Fire fighters must be cleared by a physician (primary care physician or FD physician) before returning to work after a serious injury or illness.

Fitness/Wellness Programs. The FD provides equipment for exercise at the fire stations, including cardiovascular machines and weight machines. It does not have a formal fitness or wellness program.

Discussion

Coronary Artery Disease (CAD) and the Pathophysiology of Sudden Cardiac Death. The FF suffered a myocardial infarction and subsequent cardiac arrest en route to a structure fire. The most common risk factor for cardiac arrest and sudden cardiac death is CAD, defined as the build-up of atherosclerotic plaque in the coronary arteries [AHA 2010]. Although the FF had multiple risk factors for CAD (hypertension, smoking, obesity, lack of regular exercise, family history), he was not known to have CAD prior to his death. At autopsy, he was found not only to have CAD, but findings consistent with a prior (old) myocardial infarction.

Discussion (cont.)

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]. Most heart attacks occur when a vulnerable plaque ruptures, causing a blood clot to form and occlude a coronary artery.

Establishing the occurrence of a recent (acute) heart attack requires any of the following: characteristic EKG changes, elevated cardiac enzymes, or coronary artery thrombus. No thrombus was identified at autopsy. However, 16%–27% of postmortem examinations do not reveal the coronary artery thrombus/plaque rupture during acute heart attacks [Davies 1992; Farb et al. 1995]. The FF had an EKG that showed significant ST segment changes consistent with a myocardial ischemia and infarction. The EKG, the clinical scenario, the autopsy findings of CAD and a previous heart attack and severe CAD all indicate that the FF's death was caused by an acute heart attack.

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 insulative properties of the personal protective clothing [Smith et al. 1995].

Fire Fighter Suffers Cardiac Death After Responding to a Structure Fire – New York

Discussion (cont.)

Epidemiologic studies in the general population have found that heavy physical exertion can trigger a heart attack and cause 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 [Bernard 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 FF responded to a call for a structure fire in the early morning hours. He ran to the fire station, donned his gear, and responded to the scene of a fully involved structure. He reported the onset of chest pain en route to the fire scene. Given the FF's underlying CAD, the exertion of running to the fire station, along with the adrenaline surge related to an emergency response may have triggered a heart attack and his subsequent sudden cardiac death.

Cardiomegaly/Left Ventricular Hypertrophy. The autopsy revealed that the FF had cardiomegaly and LVH. Both conditions independently increase the risk for sudden cardiac death [Levy et al. 1990]. 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 FF had a history of hypertension and probably had ischemia due to his underlying CAD. Therefore, it is likely both conditions contributed to his cardiomegaly and LVH.

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 FF was a smoker, had hypertension, was obese, and did not exercise regularly. But these conditions, by themselves, should not trigger fire fighter duty restrictions. However, the number and severity of these CAD risk factors could have warranted a referral to screen for CAD. Recommendations for conducting exercise stress tests on asymptomatic individuals without known heart disease are varied. The following paragraphs summarize the positions of widely recognized organizations on this topic.

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

Discussion (cont.)

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

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

The U.S. Preventive Services Task Force (USPSTF) does not recommend stress tests for asymptomatic individuals at low risk for coronary heart disease events. For individuals at increased risk for coronary heart disease events, the USPSTF found "insufficient evidence to recommend for or against routine screening with EKG, exercise tolerance test, or electron beam computerized tomography scanning…." Rather, 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 FF age, none of the above organizations would have "recommended" a symptom limiting exercise stress test.

Fire Fighter Suffers Cardiac Death After Responding to a Structure Fire – New York

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 exercise stress tests on FFs at risk for sudden cardiac events.

Firefighters with multiple or severe CAD risk factors or a high Framingham score are at increased risk of a sudden cardiac event [NHLBI 2010]. Neither the NFPA nor the AHA/ACC recommend exercise stress tests for asymptomatic people under the age of 45. Since this FF was 43 years old, even if the FD was following NFPA 1582 or the AHA/ACC guidelines, an exercise stress test would not have been performed. However, NIOSH investigators consider this recommendation relevant to other member of this FD.

Recommendation #2: Perform an annual physical performance (physical ability) evaluation.

NFPA 1500 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. The physical ability test could be performed as part of the FD's training program.

Recommendation #3: 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 [Stein et al. 2000; Aldana 2001]. Fire service health promotion programs have been shown to reduce CAD risk factors and improve fitness levels, with mandatory programs showing the most benefit [Dempsey et al. 2002; Womack et al. 2005; Blevins et al. 2006]. A study conducted by the Oregon Health and Science University reported a savings of more than $1 million for each of four large fire departments implementing the IAFF/IAFC wellness/fitness program compared to four large fire departments not implementing a program. These savings were primarily due to a reduction of occupational injury/illness claims with additional savings expected from reduced future nonoccupational healthcare costs [Kuehl 2007]. The FD currently has a voluntary wellness/fitness program. NIOSH recommends a formal, mandatory wellness/fitness program to ensure all members receive the benefits of a health promotion program. During exercise time, employees should be taken out of service to ensure uninterrupted participation.

References

AHA (American Heart Association) [2010]. Understand Your Risk of Heart Attack. [http://www.heart.org/HEARTORG/Conditions/HeartAttack/UnderstandYourRiskofHeartAttack/Understand-Your-Risk-of-Heart-Attack_UCM_002040_Article.jsp]. Date accessed: April 2012.

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 343:1355-1361.

Aldana SG [2001]. Financial impact of health promotion programs: a comprehensive review of the literature. Am J Health Promot 15:296-320.

Barnard RJ, Duncan HW [1975]. Heart rate and ECG responses of firefighters. J Occup Med 17(4): 247-250.

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: April 2012.

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

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.

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 well¬ness 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.

Gibbons RJ, Balady GJ, Bricker JT, Chaitman BR, Fletcher GF, Froelicher VF, Mark DB, McCallister BD, Mooss AN, O'Reilly MG, Winters WL Jr. [2002]. ACC/AHA 2002 guideline update for exercise testing: summary article: a report of the ACC/AHA Task Force on Practice Guidelines (Committee to Update the 1997 Exercise Testing Guidelines). J Am Coll Cardiol 40:1531– 40.

Hales T, Jackson S, Baldwin T [2007]. NIOSH Alert: Preventing Fire Fighter Fatalities Due to Heart Attacks and Other Sudden Cardiovascular Events. Department of Health and Human Services, Public Health Service, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health Publication No. 2007-133. [http://www.cdc.gov/niosh/docs/2007-133/]. Date Accessed: April 2012.

References (cont.)

IAFF, IAFC [2008]. The fire service joint labor man¬agement wellness/fitness initiative. 3rd ed. Washing¬ton, DC: International Association of Fire Fighters, International Association of Fire Chiefs.

Kales SN, Soteriades ES, Christoudias SG, Christiani DC [2003]. Fire fighters and on-duty deaths from coronary heart disease: a case control study. Environ Health 2(1):14.

Kales SN, Soteriades ES, Christophi CA, Chirstiani DC [2007]. Emergency duties and deaths from heart disease among fire fighters in the United States. New Engl J Med 356:1207-1215.

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.

Lemon PWR, Hermiston RT [1977]. The human energy cost of fire fighting. J Occup Med 19:558-565.

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 [2005]. The pathogenesis of atherosclerosis. In: Kasper DL, Braunwald E, Fauci AS, Hauser SL, Longo DL, Jameson JL, eds. Harrison's principles of internal medicine. 16th ed. New York, NY: McGraw-Hill, pp. 1425-1430.

Manning JE, Griggs TR [1983]. Heart rates in fire fighters using light and heavy breathing equipment: Similar near-maximal exertion in response to multiple work load conditions. J Occup Med. 25(3): 215-218.

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 329:1677-1683.

NFPA [2007a]. Standard on comprehensive occupational medical program for fire departments. Quincy, MA. NFPA 1582.

NFPA [2007b]. Standard on fire department occupational safety and health program. Quincy, MA. NFPA 1500.

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

NHLBI (National Heart, Lung, and Blood Institute) [2010]. Risk Assessment Tool for Estimating Your 10-year Risk of Having a Heart Attack. [http://hp2010.nhlbihin.net/atpiii/calculator.asp] Date accessed: April 2012.

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

References (cont.)

Shah PK [1997]. Plaque disruption and coronary thrombosis: new insight into pathogenesis and prevention. Clin Cardiol 20(11 Suppl 2):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.

Smith DL, Manning TS, Petruzzello SJ [2001]. Effect of strenuous live-drills on cardiovascular and psychological responses of recruit fire fighters. Ergonomics 44(3): 244-254.

Smith DL, Petruzzello SJ, Kramer JM, Warner SE, Bone BG, Misner JE [1995]. Selected physiological and psychobiological responses of physical activity in different configurations of firefighting gear. Ergonomics 38(10): 2065-2077.

Soteriades ES, Smith DL, Tsismenakis AJ, Baur DM, Kales SN [2011]. Cardiovascular disease in US firefighters: a systematic review. Cardiology In Review 19(4):202-215.

Stein AD, Shakour SK, Zuidema RA [2000]. Financial incentives, participation in employer sponsored health promotion, and changes in employee health and productivity: HealthPlus health quotient program. J Occup Environ Med 42:1148-1155.

Tofler GH, Muller JE, Stone PH, Forman S, Solomon RE, Knatterud GL, Braunwald E [1992]. Modifiers of timing and possible triggers of acute myocardial infarction in the Thrombolysis in Myocardial Infarction Phase II (TIMI II) Study Group. J Am Coll Cardiol 20:1049-1055.

USPSTF [2004]. U.S. Prevention Services Task Force. Screening for coronary heart diease: Recommendation Statement. Ann Intern Med 140:569-572.

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 329:1684-1690.

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 Ex¬erc 37(5):S385.

Fire Fighter Suffers Cardiac Death After Responding to a Structure Fire – New York

Investigator Information

This incident was investigated by the NIOSH Fire Fighter Fatality Investigation and Prevention Program, Cardiovascular Disease Component located in Cincinnati, Ohio. Clara Sue Ross, MD, led the investigation and coauthored the report. Dr. Ross is a board-certified occupational medicine physician. She 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 Heath and Vice Chair of the Public Safety Medicine Section of the American College of Occupational and Environmental Medicine (ACOEM).

Appendix A

Autopsy Findings

- Heart Size/Structure
  - Heart is markedly enlarged, weighing 780 grams
  - Left ventricular hypertrophy (left ventricular wall = 1.8 cm)
  - Fibrous scarring in the posterior wall of left ventricle (1.5 x 1.0 x 3.0 cm)
- Coronary Arteries
  - Severe calcific artherosclerotic changes resulting in approximately:
    - 85% narrowing of left anterior descending coronary artery,
    - Nearly occluded left circumflex coronary artery
    - Approximately 80% narrowing of the right coronary artery
- Microscopic Evaluation
  - Extensive fibrous scarring with neovascularization
  - Myofiber hypertrophy