2010
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Death in the line of duty...

NIOSH
Fire Fighter Fatality Investigation and Prevention Program

A summary of a NIOSH fire fighter fatality investigation *June, 2010*

Major Suffers Sudden Cardiac Death During Physical Fitness Training – Kentucky

Executive Summary

On January 17, 2010, a 51-year-old male volunteer Major responded to a reported residential fire. The reported fire turned out to be steam from a shower. Three hours after returning home, the Major went to exercise at a local fitness facility with his trainer. After walking on a treadmill for approximately 25 minutes, the Major had a short cool down period when he suddenly collapsed. Cardiopulmonary resuscitation (CPR) and advanced life support were begun as an ambulance was requested. Despite CPR and advanced life support by the fitness center staff, fire department (FD) emergency medical technicians, ambulance paramedics, and hospital's emergency department (ED) staff, the Major died. The death certificate, completed by the attending physician, listed "ischemic heart disease with cardiac arrest" due to "coronary artery disease" as the cause of death. The autopsy, completed by the County Coroner, listed "ischemic heart disease" as the cause of death. Given the Major's severe underlying coronary artery disease (CAD), NIOSH investigators concluded that the physical exertion involved in performing physical fitness training triggered his sudden cardiac death.

NIOSH investigators offer the following recommendations to address general safety and health issues. It is unclear if these recommendations would have prevented the Major's death.

Perform an annual physical performance (physical ability) evaluation.

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

Introduction & Methods

On January 17, 2010, a 51-year-old male volunteer Major died after performing physical fitness training. NIOSH was notified of this fatality on January 19, 2010, by the U.S. Fire Administration. NIOSH contacted the affected FD on February 5, 2010, to gather additional information, and on March 17, 2010, to initiate the investigation. On March 25, 2010, a safety and occupational health specialist from the NIOSH Fire Fighter Fatality Investigation Team traveled to Kentucky to conduct an on-site investigation of the incident.

During the investigation, NIOSH personnel interviewed the following people:

- Fire Chief
- Fire Marshal
- Safety Officer
- Crewmembers
- Fitness center Director

NIOSH personnel reviewed the following documents:

- FD training records
- FD annual report for 2009
- FD incident report
- FD medical records
- Emergency medical service (ambulance) incident report
- Hospital ED records
- Death certificate
- Autopsy report
- Primary care provider medical records
- Fitness center report

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Investigative Results

Incident. On January 17, 2010, the FD was dispatched to a residential structure fire at 1330 hours. The Major, on call for the weekend, responded from his home to the scene. Units arrived on the scene at 1337 hours and determined the "smoke" was actually steam from a shower. Units were released from the scene at 1340 hours.

The Major went home for approximately 3 hours. At approximately 1700 hours, he went to a local fitness facility to exercise. He had joined the facility at the beginning of January and a trainer was assigned to assist him with his fitness program. After speaking with the trainer, the Major walked on the treadmill for 5 minutes to warm up and have his heart rate checked; his heart rate was 100 beats per minute. The trainer then showed the Major various aspects of the treadmill and the Major walked for an additional 20 minutes. The Major's heart rate was checked three times and remained around 100 beats per minute. After cooling down, the Major walked to the hallway, drank some water, and returned to the exercise room and the trainer. As the trainer turned to speak to someone, the Major collapsed.

911 was called and an advanced life support ambulance and the FD were dispatched at 1740 hours. Fitness center staff retrieved an automated external defibrillator (AED) as CPR was begun. Two off-duty nurses were exercising at the facility and came to render aid. As the fitness center staff attempted to apply the AED, a nurse said she felt a pulse; the AED was not used.

The FD engine arrived on the scene at 1744 hours. Fire fighter/EMTs found the Major unresponsive, not breathing, with no pulse, and CPR in progress. EMTs inserted a nasal airway and attached the AED to the Major, which advised a shock (defibrillation). One shock was delivered.

The advanced life support ambulance staffed with paramedics arrived on the scene at 1749 hours. The AED advised to shock again, and a second shock was delivered. CPR continued; the Major was placed into the ambulance where he was intubated. Tube placement was confirmed by end tidal CO2 detector [AHA 2005]. Intravenous access was attained and cardiac resuscitation medications were administered as the ambulance departed the scene at 1758 hours en route to the hospital's ED. Advanced life support continued during the 9 minute trip to the hospital.

The ambulance arrived at the ED at 1807 hours. Inside the ED, advanced life support continued without change in the Major's condition until 1817 hours, when the attending physician pronounced the Major dead and resuscitation efforts were discontinued.

Medical Findings. The death certificate, completed by the attending physician, listed "ischemic heart disease with cardiac arrest" due to "coronary artery disease" as the cause of death. The autopsy, completed by the County Coroner, listed "ischemic heart disease" as the cause of death. Specific findings from the autopsy are listed in Appendix A.

The Major was 74 inches tall and weighed 253 pounds, giving him a body mass index (BMI) of 32.5 kilograms per meters squared (kg/m2). A BMI > 30.0 kilograms per meter squared is considered obese [CDC 2010]. The Major's risk factors for coronary artery disease (CAD) included hypercholesterolemia (high blood cholesterol) and obesity/lack of exercise. He had not been pre-

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Investigative Results (cont.)

scribed any lipid-lowering medications and had begun a self-initiated exercise program in January 2010.

In 2001, the Major was evaluated for acute chest discomfort. An echocardiogram revealed right ventricular hypertrophy (thickened right ventricle). He performed an exercise stress test at which he exercised for 11 minutes, 15 seconds on the Bruce protocol and stopped due to shortness of breath and fatigue. The test was deemed negative for ischemia and infarction, and the Major was cleared for duty.

At a FD medical evaluation in 2001, the Major was diagnosed with mild sleep apnea but this was not considered serious enough to restrict his duties as a fire fighter. However, in 2007 his primary care physician referred the Major to a sleep clinic. At a FD medical evaluation in 2008, the physician required the Major to get a clearance from his primary care physician regarding his sleep apnea; specifically, that the condition had been treated adequately for over 30 days. He was subsequently prescribed a continuous positive airway pressure (CPAP) machine for his sleep apnea. At this FD medical evaluation, the Major performed an exercise stress test at which he exercised for 10 minutes, 30 seconds on the Bruce protocol, reaching Stage 4 and 13 metabolic equivalents. The test was deemed negative for ischemia and was stopped due to reaching his target heart rate.

Description of the Fire Department

At the time of the NIOSH investigation, the combination FD consisted of one fire station with 54 uniformed personnel that served 28,000 residents in a geographic area of 7.3 square miles. In 2009, the FD responded to 791 calls including 287 structure fires, 16 field fires, 11 trash fires, 10 vehicle fires, 2 dumpster fires, 82 hazardous condition calls, 18 hazardous material calls, 24 false calls, 30 assist calls, 157 other calls, and 154 first responder calls.

Employment, Membership, and Training. The FD requires new career fire fighter applicants to be State-certified to the 150-hour level, complete an application, be 18 years of age (21 years old to drive fire apparatus), have a valid State driver's license, pass a written examination, pass a physical ability test, and pass an interview prior to being hired. The new hire must then pass a drug screen, a preplacement medical evaluation (including exercise stress test), and a self-contained breathing apparatus mask fit test. The new hire is placed on a shift where the hours of duty are 24 hours on-duty and 48 hours off-duty. Volunteer fire fighter applicants must complete an application, be 18 years of age (21 years old to drive fire apparatus), have a valid State driver's license, pass a written examination, pass a physical ability test, and pass an interview prior to being offered membership. The new member must then pass a drug screen, a preplacement medical evaluation (including exercise stress test), and a self-contained breathing apparatus mask fit test. If the volunteer member is previously State-certified, the fire fighter is fast tracked through the probationary period. Kentucky requires minimum training levels for fire fighters (150-hours for volunteers; 400-hours for career). The Major was certified as a Fire Officer, Fire Fighter II, Driver/Operator, EMT-D, Hazard-

ous Materials Technician, Arson Investigator, Fire Instructor (KY and IN), Fire Inspector, Wildland Fire Fighter, First Responder, Technical Rescue, and Trench Rescue. He was a Deputy State Fire Marshal and had 32 years of fire fighting experience.

Preplacement Medical Evaluations. The FD requires preplacement medical evaluations for all fire fighter applicants. Components of the evaluation include the following:

A complete medical history
Physical examination (including vital signs)
Complete blood count with lipid panel
Pulmonary function test
Audiogram
Vision screen
Urinalysis
Urine drug screen
Spirometry
Resting EKG
Stress EKG
Chest x-ray (baseline)

These evaluations are performed by a physician contracted with the City. Once this evaluation is complete, the contracted physician makes a determination regarding medical clearance for wearing a respirator and firefighting duties and forwards this decision to the FD. The Major joined this FD in 1978. The earliest FD medical evaluation available to NIOSH was in 1992.

Periodic Medical Evaluations. The FD requires periodic (annual) medical evaluations for all members. Components of the evaluation are the same as the preplacement medical evaluation except the EST is performed every 3 years and the chest x-ray is performed as indicated. The Major's last periodic medical evaluation was May 2009 at which time he was cleared to wear a respirator and was deemed fit for duty. His cholesterol/high density lipoprotein ratio was elevated at 5.0 (normal is < 4.0)

An annual SCBA medical clearance and an annual SCBA facepiece fit test are required. An annual physical ability test is not required. Members injured on duty must be evaluated by the FD-contracted physician, who makes the final determination regarding return to duty.

Health and Wellness Programs. The FD does not have a formal wellness/fitness program, but exercise equipment is available in the fire station. An annual physical ability test is not required.

Discussion

Atherosclerotic Coronary Artery Disease. In the United States, atherosclerotic CAD 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 CAD, smoking, high blood pressure, high blood cholesterol, obesity/physical inactivity, and diabetes [AHA 2010; NHLBI 2010]. The Major had four CAD risk factors (age over 45, male gender, high blood cholesterol, and obesity), and had severe CAD on autopsy.

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

Discussion (cont.)

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 the occurrence of a recent (acute) heart attack requires any of the following: characteristic electrocardiogram (EKG) changes, elevated cardiac enzymes, or coronary artery thrombus. In the Major's case, EKGs did not reveal a heart rhythm indicative of a heart attack, his cardiac enzymes were not tested, and no thrombus was definitively identified at autopsy. Therefore, it cannot be stated with certainty that the Major suffered an acute heart attack. The autopsy revealed a "questionable recanalized thrombus." A recanalized thrombus is a finding suggestive of a remote (years previously) heart attack, that, in the case of the Major, was probably asymptomatic.

Epidemiological studies have found that heavy physical exertion sometimes immediately precedes and triggers the onset of acute heart attacks and sudden cardiac death [Siscovick et al. 1984; Tofler et al. 1992; 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 Major responded to an alarm and performed physical fitness training. The fitness activity expended about 5 metabolic equivalents (METs), which is considered light physical activity [AIHA 1971; Gledhill and Jamnik 1992]. Given the Major's underlying CAD, the stress of performing physical fitness training probably triggered an arrhythmia or a heart attack that resulted in his sudden cardiac death.

Cardiomegaly/Left Ventricular Hypertrophy. On autopsy, the Major was found to have left ventricular hypertrophy (LVH) and an enlarged heart (cardiomegaly). Both LVH and cardiomegaly 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 high blood pressure (hypertension), a heart valve problem, chronic cardiac ischemia (reduced blood supply to the heart muscle), or obstructive sleep apnea [Siegel 1997]. The Major did not have a history of hypertension or a heart valve problem. Therefore, his LVH was probably due to chronic cardiac ischemia and/or his sleep apnea (discussed below).

Sleep Apnea. The Major was diagnosed with sleep apnea in June 2001. The U.S. DOT will not grant a commercial driver's license if a person has a clinical diagnosis of a respiratory dysfunction likely to interfere with his/her ability to control and drive a commercial motor vehicle safely [49 CFR1 391.41]. A medical expert panel has recommended that the Federal Motor Carrier Safety Administration's current guidelines pertaining to individuals who have obstructive sleep apnea be replaced with the following statement: "A diagnosis of obstructive sleep apnea precludes an individual from obtaining unconditional certification to drive a commercial motor vehicle for the purposes of interstate commerce" [Ancoli-Israel et al. 2008].

NFPA 1582 identifies sleep apnea as a "disorder of respiratory regulation that can result in gas ex-

Discussion (cont.)

change abnormalities that prevent the safe performance" of fire fighting tasks, wearing an SCBA, climbing 6 or more flights of stairs while wearing turnout gear, advancing charged hoselines, and prolonged extreme physical exertion [NFPA 2007a]. It is unclear if the Major's sleep apnea was serious enough to result in job restrictions per NFPA 1582.

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 2007a]. This voluntary industry standard provides (1) the components of a preplacement and annual medical evaluation and (2) medical fitness for duty criteria. Exercise stress tests screen people at risk for CAD and sudden cardiac death. NFPA 1582 recommends an exercise stress test performed "as clinically indicated by history or symptoms." The Major had EST's in 2001 and 2008 which showed no evidence of ischemia. Based on subsequent events, it is likely that these were false negative results.

Recommendations

NIOSH investigators offer the following recommendations to address general safety and health issues. It is unclear if these recommendations would have prevented the Major's death.

Recommendation #1: Perform an annual physical performance (physical ability) evaluation.

NFPA 1500, Standard on Fire Department Occupational Safety and Health Program, requires the FD to develop physical performance requirements for candidates and members who engage in emergency operations [NFPA 2007b]. Members who engage in emergency operations must be annually qualified (physical ability test) as meeting these physical performance standards for structural fire fighters [NFPA 2007b].

Recommendation #2: Phase in a 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 the National Volunteer Fire Council (NVFC)'s Health and Wellness Guide, and in Firefighter Fitness: A Health and Wellness Guide [USFA 2004; 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

Recommendations (cont.)

health promotion programs have been shown to reduce coronary artery disease 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].

Given the FD's structure, the NVFC program might be the most appropriate model [USFA 2004]. NIOSH recommends a formal, structured wellness/fitness program to ensure all members receive the benefits of a health promotion program.

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

Appendix A

Autopsy Findings

- Severe atherosclerotic cardiovascular disease
  - Severe (90%) focal narrowing of the left anterior descending coronary artery
  - "Questionable" recannalized thrombus
- Cardiomegaly (enlarged heart) (heart weighed 550 grams [g]; predicted normal weight is 418 g [ranges between 316 g and 551 g] as a function of sex, age, and body weight) [Silver and Silver 2001]
- Left ventricular hypertrophy (LVH)
  Left ventricular wall and interventricular septum thickened (2.0 centimeters [cm] and 1.6 cm respectively;
    - normal by autopsy 0.76–0.88 cm [Colucci and Braunwald 1997];
    - normal by echocardiography 0.6–1.1 cm [Armstrong and Feigenbaum 2001]
- Right ventricular dilatation
- Microscopic evidence of myocyte hypertrophy, mild subendocardial myocytolysis, and focal and interstitial fibrosis
- Normal cardiac valves
- No evidence of a pulmonary embolus (blood clot in the lung arteries)
- Blood tests for drugs and alcohol were negative

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