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NIOSH

Fire Fighter Fatality Investigation and Prevention Program

Death in the line of duty...

A Summary of a NIOSH fire fighter fatality investigation *September 14, 2005*

Lieutenant Suffers Sudden Cardiac Death at the Scene of a Structure Fire – South Carolina

SUMMARY

On April 22, 2004, a 56-year-old male volunteer Lieutenant (LT) responded to a fire in the city community center. After donning his turnout gear, the LT walked toward the pumper when he suddenly collapsed. Ambulance service paramedics on the scene provided immediate treatment. Despite cardiopulmonary resuscitation (CPR) and advanced life support (ALS) performed by the paramedics and hospital emergency department (ED) personnel, the LT died. The death certificate, completed by the County Coroner, listed "acute myocardial infarction" due to "viral endocarditis" as the cause of death. No autopsy was performed. The NIOSH investigator concluded the physical stress of responding to the structure fire and the LT's underlying dilated cardiomyopathy contributed to his sudden cardiac death.

NIOSH investigators offer the following recommendations to prevent similar incidents or to address general safety and health issues:

Provide pre-placement and annual medical evaluations to ALL fire fighters to determine their medical ability to perform duties without presenting a significant risk to the safety and health of themselves or others.

Consider conducting exercise stress tests for male fire fighters over the age of 45 years with two or more risk factors for coronary artery disease.

***Ensure that fire fighters are cleared for duty by a physician knowledgeable about the physical demands of fire fighting, the personal protective equipment used by fire fighters, and the various components of NFPA 1582,* Standard on Comprehensive Occupational Medicine Program for Fire Departments.**

Phase in a mandatory wellness/fitness program for fire fighters to reduce risk factors for cardiovascular disease and improve cardiovascular capacity.

Perform an annual physical performance (physical ability) evaluation to ensure fire fighters are physically capable of performing the essential job tasks of structural fire fighting.

Perform an autopsy on all on-duty fire fighter fatalities.

INTRODUCTION & METHODS

On April 22, 2004, a 56-year-old male LT suffered sudden cardiac death after responding to a structure fire. Despite CPR and ALS performed by ambulance service personnel and hospital ED personnel, the LT died. NIOSH was notified of this fatality on April 23, 2004, by the United States Fire Administration. NIOSH contacted the affected fire department (FD) on May 25, 2004, to obtain further information, and on April 27, 2005, to initiate the investigation. On May 19, 2005, a Safety and Occupational Health Specialist from the NIOSH Fire

The **Fire Fighter Fatality Investigation and Prevention Program** is conducted by the National Institute for Occupational Safety and Health (NIOSH). The purpose of the program is to determine factors that cause or contribute to fire fighter deaths suffered in the line of duty. Identification of causal and contributing factors enable researchers and safety specialists to develop strategies for preventing future similar incidents. The program does not seek to determine fault or place blame on fire departments or individual fire fighters. To request additional copies of this report (specify the case number shown in the shield above), other fatality investigation reports, or further information, visit the Program Website at **www.cdc.gov/niosh/firehome.html** or call toll free **1-800-35-NIOSH**

Fighter Fatality Investigation and Prevention Team and an Association of Teachers of Preventive Medicine (ATPM) intern traveled to South Carolina to conduct an on-site investigation of the incident.

During the investigation NIOSH personnel met and/or interviewed the following people:

- Fire Chief
- LT's wife

During the site visit NIOSH personnel reviewed the following documents:

- FD incident report
- Primary care physician (PCP) records
- Cardiologist records
- Ambulance report
- Hospital ED report
- Death certificate

INVESTIGATIVE RESULTS

On April 22, 2004, the involved FD was dispatched at 1556 hours to a fire in a remodeled local junior high school building. The junior high was a two-story building of heavy timber construction with a community gym, cafeteria, dressing rooms, and an art gallery.

Three engine companies, 20 fire fighters, and an ambulance responded to the call. Fire units began to arrive on the scene at 1559 hours to find heavy fire involving much of the structure. Mutual aid was requested from four neighboring fire departments. Three additional engines, two tankers, one ladder, and fifteen personnel responded via mutual aid. The ambulance arrived on the scene at 1601 hours to provide emergency medical services (EMS) standby.

The LT responded from his home and arrived on the scene at about 1610 hours. He donned his turnout gear (pants, coat, boots, helmet, and gloves) and began to walk down the hill to the fire apparatus. He had been placed on light duty, restricted to external support duties, and was preparing to assist the apparatus operators. He had walked a short distance, when, at about 1612 hours, he suddenly collapsed. Crew members and nearby EMS personnel immediately went to his aid.

Upon finding the LT unresponsive, with no pulse and no respirations, nearby personnel began CPR. A second ambulance was requested for assistance and arrived on the scene at 1614 hours. CPR was in progress, an oral airway had been placed, and respirations were being provided via bag-valve-mask. A cardiac monitor was connected to the LT, revealing ventricular fibrillation (Vfib), and one shock was delivered. The LT's heart rhythm reverted to asystole (no heart beat). External cardiac pacing was performed, achieving electrical capture with radial and carotid pulses at a rate of 60 beats per minute. The LT was intubated (a breathing tube inserted into the trachea). Lung sounds were confirmed with bilateral auscultation. External pacing became ineffective, CPR was restarted, and an intravenous (IV) line was placed. When the LT was placed into the ambulance, the intubation tube became displaced. He was re-intubated and lung sounds were confirmed with bilateral auscultation and measurement of end-tidal carbon dioxide. His heart rhythm reverted to asystole, and cardiac resuscitation medications were administered. The ambulance departed the scene en route to the hospital at 1627 hours. En route, additional cardiac resuscitation medications were given, and two additional defibrillation attempts were made without change in the LT's status.

The ambulance arrived at the hospital ED at 1648 hours. Inside the ED, ALS resuscitation measures were continued. After a total of 59 minutes of CPR and 58 minutes of ALS, there was no improvement in the LT's condition. At 1712 hours, the attending physician pronounced the LT dead, and resuscitation measures were discontinued.

Medical Findings. The death certificate, completed by the County Coroner, listed "acute myocardial infarction (MI)" due to "viral endocarditis" as the cause of death. No autopsy was performed.

At his last medical check up in March 2004, the LT weighed 230 pounds and was 72 inches tall, giving him a body mass index (BMI) of 31.1 kilograms per square meter (kg/m^2). A BMI 30 kg/m^2 and over is considered obese[1]. The LT had a history of high blood lipids that was successfully treated with diet and exercise. He was never prescribed medications for his blood lipids, and his last readings in August 2003 were normal.

In August 2003, the LT was hospitalized for shortness of breath while lying down, and to rule out a MI, a previous (old) inferior and a possible septal MI. An echocardiogram revealed a left ventricular ejection fraction (LVEF) of 25%, moderate mitral regurgitation, moderate pulmonary hypertension, severely elevated pulmonary capillary wedge pressure, severely elevated left ventricular end-diastolic pressure, and a reduced cardiac output; findings consistent with severe congestive heart failure. A cardiac catheterization revealed minimal coronary artery disease (CAD) (normal left main coronary artery, 30% stenosis in the left anterior descending coronary artery, 30% stenosis in the left circumflex coronary artery, and 20% stenosis in the right coronary artery). The LT's blood test for MI (troponin, a more definitive test for an MI) was negative, and he was diagnosed with nonischemic dilated cardiomyopathy (DCM). In addition, he was found to have heart conduction problems (a prolonged QT interval on his EKG and non-sustained ventricular tachycardias on cardiac monitoring). He was prescribed multiple cardiac medications including an anticoagulant, two diuretics, digoxin, and two anti-hypertensives. His symptoms improved and he was discharged 3 days later.

A follow-up visit to his cardiologist in December 2003 revealed new EKG findings of premature ventricular complexes and a left bundle branch block pattern. At this time, the LT had been going to cardiac rehabilitation regularly and was working full time as a supervisor at a local factory. Five days later, the LT was hospitalized for an episode of atrial fibrillation. Telemetry (cardiac monitoring) showed atrial fibrillation and intermittent episodes of nonsustained ventricular tachycardia. An anti-arrhythmic agent was added to his other medications, and he was discharged.

By March 2004, with treatment, the LT's condition markedly improved. His shortness of breath had resolved and his LVEF had improved to 41% by multigated acquisition (MUGA) (a form of radionuclide imaging) scan. A Doppler echocardiogram revealed a dilated hypokinetic left ventricle and dilated left atrium. There was moderate global hypokinesis with the ejection fraction at about 40%.

According to the LT's wife, the LT was active, worked around the house, and worked 12-hour days as a local factory supervisor, but did not currently perform regular strenuous exercise. He had no recent complaints of chest pain or other cardiac symptoms. The FD had placed the LT on light duty in August 2003, and the LT had responded to other calls since then.

DESCRIPTION OF THE FIRE DEPARTMENT

At the time of the NIOSH investigation, this volunteer FD consisted of 27 uniformed personnel, served a population of 2,000, and had one fire station.

Training. The FD requires all fire fighter applicants to possess a valid state driver's license. After an interview with the Fire Chief, applicants must be recommended to the general membership, and be voted on prior to selection. The member is then placed on 6-month probation and begins an 80-hour structural fire fighting training program. After the

6-month probationary period, the member is voted on for full membership. State fire fighter certification is voluntary. There is no state mandatory annual refresher training. The state fire training is conducted in accordance with Occupational Safety and Health Administration (OSHA) requirements for fire departments. The minimum FD requirement for interior structural fire fighting is the 80-hour structural fire fighting training program.

The LT was certified as an interior structural fire fighter and had 28 years of fire fighting experience.

Pre-placement Physical Examination. No pre-placement physical examination is required by this FD, however the membership application queries the applicant regarding physical fitness.

Periodic Evaluations. No periodic medical evaluations, physical agility test, or wellness/fitness programs are required by this FD for budgetary reasons and concerns that such requirements would hamper recruitment efforts. No return-to-duty medical clearance is required for illnesses and injuries that temporarily prevent fire fighters from performing their duty. Annual self-contained breathing apparatus clearance is required.

DISCUSSION

Dilated Cardiomyopathy and Sudden Cardiac Death. The cardiomyopathies (CM) constitute a group of diseases involving the heart muscle. They are distinctive because the damage to the heart muscle is not the result of hypertensive, ischemic (coronary artery), valvular, pericardial, or congenital disease.[2] There are three types of CM based on functional impairment:

1) dilated (DCM), the most common form, accounts for 60% of all cardiomyopathies
2) hypertrophic (HCM), recognized by inappropriate left ventricular hypertrophy often with involvement of the interventricular septum
3) restrictive (RCM), the least common form in western countries, marked by impaired diastolic filling and in some cases with endocardial scarring of the ventricle[2]

DCM, the type diagnosed in the LT, is characterized by cardiac enlargement and impaired systolic function of one or both ventricles.[3] As the ventricular function deteriorates, signs and symptoms of congestive heart failure (CHF) appear: shortness of breath with exertion or lying flat, ankle swelling, fatigue, weakness, etc. The LT had many of these symptoms prior to his hospitalization. As in the case with the LT, laboratory studies (radionuclide and cardiac catheterization) reveal left ventricular enlargement and dysfunction, mitral and/or tricuspid regurgitation, elevated left- and often right-sided filling pressures, elevated pulmonary artery wedge pressures, and diminished cardiac output.[2,3]

The incidence rate of DCM in the United States is 5 to 8 cases per 100,000 per year with an age-adjusted prevalence of 36 cases per 100,000.[4] Most cases of DCM are of unknown etiology (idiopathic), although a variety of acquired or hereditary disorders can cause the disorder (Table 1).[3] In the LT's case, viral myocarditis is a possible cause, particularly given the County Coroner's listing of "viral endocarditis" as a contributing factor on the death certificate. However, with the available medical records, NIOSH investigators were not able to find any reference to an episode of viral myocarditis. In addition, NIOSH investigators are not aware of viruses being capable of causing ENDOcarditis as listed on the death certificate. The LT did not have any heart valve vegetations or significant valve dysfunction consistent with endocarditis on his echocardiogram 1 month before his death.

Once diagnosed with DCM, patients typically have a downhill course. Patients over the age of 55 usually die within 3 years of the onset of symptoms.[2]

DCM is also associated with an increased incidence of sudden cardiac death (SCD), mostly from arrhythmias.[2,3,5] Although a variety of symptoms and medical tests can provide prognostic information, patients at greatest risk of SCD are hard to identify.[3] The LT was already on a potent anti-arrhythmic medication and, given his relatively good LVEF, was not a candidate for an implanted defibrillator.[5]

The County Coroner listed "acute myocardial infarction" as the immediate cause of death on the death certificate. To definitively diagnose an acute myocardial infarction requires any of the following: a blood clot (thrombus) in the coronary artery found by catheterization or autopsy, blood tests (cardiac isoenzymes), or EKG findings. The LT did not have an autopsy or an emergent catheterization to identify a thrombus; he died prior to the cardiac isoenzymes becoming positive, and he did not have any heartbeat to conduct an EKG. Given the LT's known history of ventricular arrhythmias, increased risk of SCD due to his DCM, and his relatively clean coronary arteries during his cardiac catheterization 8 months earlier, NIOSH investigators feel his death was most likely due to a cardiac arrhythmia associated with his DCM. The emotional stress and light physical exertion while responding to this incident, coupled with his underling DCM probably triggered his SCD.

Given the LT's DCM diagnosis, restricting him from interior fire suppression and strenuous activity was entirely appropriate. These restrictions were consistent with guidance from the National Fire Protection Association (NFPA) 1582, *Standard on Comprehensive Occupational Medical Program for Fire Departments*.[6] Despite these restrictions and the medical treatment for his condition, the LT suffered SCD. Because many cases of DCM can be inherited in an autosomal dominant pattern, the LT's first-degree relatives may want to consult with their physicians regarding the utility of a screening EKG and/or a screening echocardiogram.[7,8,9]

RECOMMENDATIONS

The following recommendations are unlikely to have prevented this LT's SCD. However, if implemented, NIOSH investigators feel the FD reduce the risk of SCD in other fire fighters.

Recommendation #1: Provide pre-placement and annual medical evaluations to ALL fire fighters to determine their medical ability to perform duties without presenting a significant risk to the safety and health of themselves or others.

Guidance regarding the content and frequency of pre-placement and periodic medical evaluations and examinations for structural fire fighters can be found in NFPA 1582, *Standard on Comprehensive Occupational Medical Program for Fire Departments*,[6] in the report of the International Association of Fire Fighters/International Association of Fire Chiefs (IAFF/IAFC) *Wellness/Fitness Initiative*,[10] and the National Volunteer Fire Council (NVFC) *Health and Wellness Guide*.[11] The FD is not legally required to follow any of these standards.

Applying this recommendation involves economic repercussions and may be particularly difficult for small, rural, volunteer fire departments to implement. To overcome the financial obstacle, the FD could urge current members to get annual medical clearances from their private physicians. Another option is having the annual medical evaluations recommended by NFPA 1582 completed by other members of the volunteer FD (medical and occupational history) and by EMTs from the county's EMS (vital signs, height, weight, visual acuity, EKG). This information could then be provided to a community physician, perhaps volunteering his or her time, to review the data and provide medical clearance (or further evaluation, if needed). The more extensive portions of the medical examinations could be performed by a private physician at the fire fighter's expense, provided by a physician volunteer, or paid for by the FD. Sharing the financial responsibility for these evaluations be-

tween volunteers, the FD, and physician volunteers may reduce the negative financial impact on recruiting and retaining needed volunteers.

Recommendation #2: Consider conducting exercise stress tests for male fire fighters over the age of 45 years with two or more risk factors for coronary artery disease.

NFPA 1582 and the IAFF/IAFC *Wellness/Fitness Initiative* recommend EST for fire fighters with two or more CAD risk factors.[6,10] The American Heart Association (AHA) states EST may be indicated for individuals who are over 45 years of age with two or more risk factors for CAD.[12] The EST could be conducted by the fire fighter's personal physician or the City/County contract physician. If the fire fighter's personal physician conducts the test, the results should be communicated to the appropriate FD representative.

***Recommendation #3: Ensure that fire fighters are cleared for duty by a physician knowledgeable about the physical demands of fire fighting, the personal protective equipment used by fire fighters, and the various components of NFPA 1582,* Standard on Comprehensive Occupational Medicine Program for Fire Departments.**

Physicians providing input regarding medical clearance for fire fighting duties should be knowledgeable about the physical demands of fire fighting and should recognize that fire fighters frequently respond to incidents in environments that are immediately dangerous to life and health. They should also be familiar with a FF's personal protective equipment and the consensus guidelines published by NFPA 1582.[6] To ensure physicians are aware of these guidelines, we recommend that the FD, or the FF, provide personal physicians with a copy of NFPA 1582.

Recommendation #4: Phase in a mandatory wellness/fitness program for fire fighters to reduce risk factors for cardiovascular disease and improve cardiovascular capacity.

Physical inactivity is the most prevalent modifiable risk factor for CAD in the United States. Additionally, physical inactivity, or lack of exercise, is associated with other risk factors, namely obesity and diabetes.[13] NFPA 1500, *Standard on Fire Department Occupational Safety and Health Program*, requires a wellness program that provides health promotion activities for preventing health problems and enhancing overall well-being.[14] NFPA 1583, *Standard on Health-Related Fitness Programs for Fire Fighters*, provides the minimum requirements for a health-related fitness program.[15] In addition, the NVFC *Health and Wellness Guide* addresses wellness/fitness programs as they relate to volunteer fire departments.[11]

Recommendation #5: Perform an annual physical performance (physical ability) evaluation to ensure fire fighters are physically capable of performing the essential job tasks of structural fire fighting.

NFPA 1500 requires fire department members who engage in emergency operations to be annually evaluated and certified by the fire department as meeting the physical performance requirements identified in paragraph 8-2.1.[14]

Recommendation #6: Perform an autopsy on all on-duty fire fighter fatalities.

In 1995, the United States Fire Administration (USFA) published the Firefighter Autopsy Protocol.[16] With this publication the USFA hopes to provide "a more thorough documentation of the causes of firefighter deaths for three purposes:

1. to advance the analysis of the causes of firefighter deaths to aid in the development of improved firefighter health and safety equipment, procedures, and standards;

2. to help determine eligibility for death benefits under the Federal government's Public Safety Officer Benefits Program, as well as state and local programs; and

3. to address an increasing interest in the study of deaths that could be related to occupational illnesses among firefighters, both active and retired."

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Table 1. Known Causes of Dilated Cardiomyopathy[3]

Toxins
- Ethanol
- Chemotherapeutic agents (doxorubicin, bleomycin)
- Cobalt
- Anti-retroviral agents (zidovudine, didanosine, zalcitabine)
- Phenothiazines
- Carbon monoxide
- Lead
- Cocaine
- Mercury

Metabolic Abnormalities
- Nutritional deficiencies (thiamine, selenium, carnitine)
- Endocrinologic disorders (hypothyroidism, acromegaly, thyrotoxicosis,
- Cushing's Disease, pheochromocytoma, diabetes mellitus)
- Electrolyte disturbances (hypocalcemia, hypophosphatemia)

Infectious
- Viral (coxsackie virus, cytomegalovirus, human imunodeficiency virus)
- Rickettsial
- Bacterial (diphtheria)
- Mycobacterial
- Fungal
- Parasitic (toxoplasmosis, trichinosis, Chagas' disease)

Noninfectious
- Collagen vascular disorders (scleroderma, lupus erythematosus, dermatomyositis)
- Hypersensitivity myocarditis
- Sarcoidosis
- Peripartum dysfunction

Neuromuscular Causes
- Duchenne's muscular dystrophy
- Facioscapulohumeral muscular dystrophy
- Erb's limb-girdle dystrophy
- Myotonic dystrophy