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23

Death in the line of duty...

NIOSH
Fire Fighter Fatality Investigation and Prevention Program

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

Lieutenant Suffers Sudden Cardiac Death at Home following 24-hr Shift - Illinois

Executive Summary

On July 1, 2010, a 37-year-old career Lieutenant (LT) died at his home after serving a 24-hr shift the preceding day. The LT had responded to two fire calls and two emergency medical calls during his duty shift. The LT was found unresponsive at his home by his 6-year old son and his son's baby sitter. The baby sitter called 911 and upon arrival, Emergency Medical System (EMS) personnel found the LT to be cyanotic with significant blood pooling (lividity). The coroner was notified and the LT was pronounced dead at the scene. The autopsy, completed by a forensic pathologist, identified "hypertrophic cardiomyopathy" as the immediate cause of death. NIOSH investigators agree with this assessment and concluded that the LT probably died from a fatal heart arrhythmia associated with undiagnosed hypertrophic cardiomyopathy.

The following recommendations would not have prevented the LT's death. Nonetheless, NIOSH offers them to reduce the risk of heart attacks and sudden cardiac arrest among fire fighters at this, and other fire departments (FD) across the country.

Consider providing symptom limiting and diagnostic imaging exercise stress tests for fire fighters based on their risk for a coronary heart disease event.

Provide a comprehensive wellness program to complement the FD's physical fitness program.

Introduction & Methods

On July 1, 2010, a 37-year-old LT died at his home approximately 6 hours after completing a 24-hour work shift. NIOSH was notified of this fatality on July 6, 2010 by the U.S. Fire Administration. NIOSH contacted the affected FD shortly thereafter and on August 10, 2010 to request further information and to schedule the investigation. On September 1, a contractor for the NIOSH Fire Fighter Fatality Investigation Team (the NIOSH investigator) travelled to Illinois to conduct an on-site investigation of the incident.

During the investigation, NIOSH personnel interviewed the following people:
- Fire Chief
- Crew members working with the LT
- Fire Fighter's Local Union President
- LT's spouse

NIOSH personnel reviewed the following documents:
- FD medical records
- Ambulance report
- Death certificate
- Medical examiner's report
- Personal physician medical records

Lieutenant Suffers Sudden Cardiac Death at Home following 24-hr Shift - Illinois

Lieutenant Suffers Sudden Cardiac Death at Home following 24-hr Shift - Illinois

Investigative Results

Work Shift. On June 30, 2010 at about 0640 hours the LT arrived at his fire station for his 24-hour shift. The LT and three firefighters were assigned to the station's Engine. The LT and his crew attended EMS classroom training in the morning for approximately 2 hours. The LT and crew then worked out in the FD's fitness room for an hour as mandated by the FD's fitness policy. The LT performed a cardiovascular workout for about 30 minutes and lifted free weights for about 30 minutes.

At 1133 hours, the LT and his crew responded to a possible car fire. On scene, the LT investigated the car and reported that a fire in the ashtray had been extinguished by security guards. The crew had lunch at the station and then spent about 2 hours in the community attaching flags to fire hydrants to increase their visibility.

At 1326 hours, the crew responded to an alarm at a school. The crew staged in the rear of the building while another company investigated a report of the smell of smoke. At 1813 hours the LT and his crew were dispatched to an EMS call with a report of an unresponsive patient with CPR in progress. The crew arrived on scene at 1817 hours and assisted EMS personnel with a patient in full cardiac arrest. The patient had collapsed on a softball diamond and the LT and another firefighter retrieved the stretcher and backboard from the ambulance and delivered it to EMS personnel providing patient care on the field. Once the patient was loaded onto the stretcher, the LT helped push the stretcher to the ambulance and load the patient into the back of the ambulance. En route to the hospital, the LT assisted with patient care, including starting an intravenous line and rotating with other personnel to provide cardiopulmonary resuscitation (CPR). The crew returned to service at 1857 hours.

The ambulance crew had dinner with the Engine crew that evening to critique the cardiac arrest call. The LT visited with crew members in the evening before going to bed. He got up at 0600 hours and left the fire station as usual. At no time during his shift did the LT report any health complaints.

On the morning of his death, the LT arrived home from his shift at approximately 0830 hours, had coffee and visited with his wife, and played with his children. At approximately 0930 hours a landscape crew arrived at his home and the LT went outside to oversee the landscape work and to do chores around his pool. The temperature was in the high 70s with a relative humidity of 57% [Weather Underground 2011]. The LT was last seen at approximately 1045 hours.

At approximately 1230 hours the LT's 6-year old son and baby sitter found the LT lying unresponsive on the deck of the pool. The babysitter called 911 and then initiated CPR. EMS was dispatched at 1237 hours and arrived on scene at 1243 hours. Upon arrival, EMS personnel found the LT unresponsive with evidence of blood pooling (lividity) suggesting the LT had been deceased for at least an hour. EMS personnel contacted the coroner's office who arrived on scene and pronounced the LT dead at 1310 hours.

Medical Findings. The death certificate and the autopsy, completed by a forensic pathologist from the County Coroner's office, listed the cause of death as hypertrophic cardiomyopathy. The autopsy found that the heart was enlarged (560 grams) and that the left ventricle was much thicker than normal [2.5 centimeters (cm)]. There was

Lieutenant Suffers Sudden Cardiac Death at Home following 24-hr Shift - Illinois

Investigative Results (cont.)

no evidence of significant atherosclerotic heart disease. See Appendix A for more complete autopsy findings.

The LT was an apparently healthy individual who rarely saw his physician. His last FD medical evaluation was on December 14, 2009 where he was noted to have borderline high cholesterol [233 milligrams per deciliter (mg/dL)] (desirable < 200 mg/dL; borderline high 200-239 mg/dL; high ≥ 240 mg/dL) [National Cholesterol Education Program 2001]. The LT was counseled by the FD physician about his cholesterol level and he modified his diet to address this concern. The LT then followed up with his personal physician. His most recent medical evaluation was on June 11, 2010 by his primary care physician. At this time the LT's total cholesterol was 211(mg/dL). The LT was very active and fit. He participated in the mandatory fitness program at the FD (30 minutes of cardiovascular exercise and 30 minutes of weight training) each duty day and exercised 1 – 2 days per week at home. The LT had a body mass index of 23.8 placing him in the normal weight category [AHA 2010]. He reported on his health history questionnaire that he smoked approximately 1.5 packs of cigarettes per day.

Description of the Fire Department

The FD consists of over 50 uniformed personnel working out of five fire stations and serving a population of approximately 27,000 residents. The FD provides services in an area of 15 square miles.

Employment and Training. The FD has two hiring programs. For individuals with no prior fire service or EMS experience, applicants must be between 21 – 35 years old, have a high school diploma (or equivalent), a valid driver's license, and no felonies. Applicants take a Physical Agility Test (PAT) and a written general knowledge test, and are interviewed by a Commission. Individuals who pass the PAT are ranked according to their scores on the written exam and interview and are placed on an eligible list.

Individuals who are already certified Firefighter II and paramedics are placed on a qualified list. Hiring preference is given to qualified candidates. Candidates hired from the qualified list must pass the PAT within 6 months of hire.

The FD has a 1-year probationary period following hire. During the first 3 years of employment, the firefighter is rotated among the various stations and the three shifts.

Post-Offer/Pre-placement Medical Evaluations. New hires receive a complete medical evaluation which includes a health history, physical examination, complete blood cell count, blood chemistry panel, cholesterol testing, urinalysis, urine drug screen, spirometry, vision testing, hearing testing, resting EKG, and chest X-ray. The LT's initial medical evaluation included a chest X-ray that found the heart to be within normal limits and identified no other abnormalities.

Description of the Fire Department (cont.)

Periodic Medical Evaluations. Members receive annual medical evaluations. The content of the periodic medical evaluation is the same at the post-offer/pre-placement evaluation except that resting EKG, chest X-ray and the urine drug test are omitted (unless indicated by the physical examination or history) and an exercise stress test is performed for fire fighters ≥40. The LT's last medical evaluation was in December 2009 at which time he was cleared for duty. It was noted that he had borderline high total cholesterol (233 mg/dL) and high LDL cholesterol (167 mg/dL).

Physical Assessments. Members receive individual physical assessments that include a PAT, an air consumption on a given course test, and a physical fitness evaluation. The PAT is performed two times per year. The consumption test and the physical fitness evaluation are performed annually. Per FD policy, the LT was provided with the results of his evaluation.

Fitness/Wellness Programs. The FD has a mandatory fitness program for firefighters. The fitness program requires that firefighters perform a minimum 30 minutes of cardiovascular exercise and 30 minutes of weight training during each duty day. Firefighters work out at the Department's fitness center, which is equipped with aerobic and weight lifting equipment.

Discussion

Cardiomyopathies are a diverse group of diseases of the heart muscle. Hypertrophic cardiomyopathy (HCM) is the most common cardiomyopathy. HCM is a genetic disease that is defined by a hypertrophied, nondilated left ventricle in the absence of another disease capable of producing a thickened wall [Maron et al. 2006]. The LT was diagnosed with HCM at autopsy based on his marked left ventricular hypertrophy with no other known diseases.

Hypertrophic Cardiomyopathy (HCM). HCM is a relatively rare heart condition, affecting approximately 0.2% of the population [Spirito et al. 1997]. Diagnosis is typically made by echocardiogram which shows the left ventricular thickening. The majority of patients are asymptomatic, and sudden cardiac death is often the first clinical manifestation [Wynne et al. 2005]. Risk factors for sudden death among HCM patients include young age (<30 years old) at diagnosis, a family history of HCM with sudden death, an abnormal blood pressure response to exercise, severe symptoms, non-sustained ventricular tachycardia, marked hypertrophy, marked left atrial dilatation, and genetic abnormalities associated with increased prevalence of sudden death [Spirito et al. 1997; Wynne et al. 2005, Olivotto et al. 1999, Maron et al. 2006].

The NIOSH investigator concludes that the LT had a fatal cardiac arrhythmia associated with his HCM. Could this diagnosis have been made prior to his death? As mentioned earlier, the LT was asymptomatic, and his baseline medical evaluation and subsequent medical evaluations did not detect any cardiac abnormality (e.g., a heart murmur or EKG abnormalities). This lack of symptoms and normal physical examination is relatively common among patients with HCM. However, even if the LT was

Lieutenant Suffers Sudden Cardiac Death at Home following 24-hr Shift - Illinois

Discussion (cont.)

diagnosed with HCM, he did not have any known risk factors associated with sudden death among HCM patients.

Occupational Medical Standards for Structural Fire Fighters. To reduce the risk of sudden cardiac death or other incapacitating medical conditions among fire fighters, the NFPA developed NFPA 1582 [NFPA 2007]. NFPA considers cardiomyopathies that result in signs or symptoms of compromised left or right ventricular function or an enlarged ventricle as a Category A medical condition for fire fighter candidates. Class A medical conditions are defined as "A medical condition that would preclude a person from performing as a member in a training or emergency operational environment by presenting a significant risk to the the safety and health of the person or others." Candidates with Category A medical conditions "shall not be certified as meeting the medical requirements of NFPA 1582." [NFPA 2007]. NFPA also specifically lists HCM a Category B medical condition for fire fighter candidates; a Category B condition is defined as "a medical condition that, based on its severity or degree, could (our emphasis) preclude a person from performing as a member in a training or emergency operational environment by presenting a significant risk to the safety and health of the person or others." The medical community has determined that HCM and idiopathic hypertrophic subaortic stenosis are actually the same condition, the distinction only being the location of the hypertrophy. NFPA 1582 notes this distinction in its members section when it states, "Hypertrophic obstructive cardiomyopathy (idiopathic hypertrophic subaortic stenosis) might compromise the member's ability to function as an integral component of a team, where sudden incapacitation can result in mission failure or in risk of injury or death to civilians or other team members [NFPA 2007].

Recommendations

The following recommendations would not have prevented the LT's death. Nonetheless, NIOSH offers them to reduce the risk of heart attacks and sudden cardiac arrest among fire fighters at this, and other fire departments (FD) across the country.

Recommendation #1: Consider providing symptom limiting and diagnostic imaging exercise stress tests for fire fighters based on their risk for a coronary heart disease event.

We applaud the FD for implementing a comprehensive medical evaluation program, and for conducting exercise stress tests for fire fighters 40 years of age and older. While age is one of the strongest predictors for a coronary heart disease event, it is not the only risk factor. The FD should take these other risk factors into account when determining who should receive exercise stress tests. The following discussion provides recommendations by NFPA, American College of Cardiology / American Heart Association (ACC/AHA), U.S. Department of Transportation (USDOT), and the U.S. Preventative Services Task Force (USPSTF) for conducting stress tests in asymptomatic people.

The National Fire Protection Association (NFPA) 1582 states, "Stress EKG with or without echocardiogram or radionuclide scanning shall be performed as clinically indicated by history or symptoms" and refers the reader to Appendix A [NFPA 2007]. Items in the Appendix A are not standard requirements, but are provided for "informational purposes only." Appendix A recommends that sub-maximal (85% of predicted heart rate) stress tests be used as a screening tool to evaluate a fire fighter's aerobic capacity. Maximal (e.g., symptom limiting) stress tests with imaging

Recommendations (cont.)

should be use for fire fighters with:
- abnormal screening sub-maximal tests
- cardiac symptoms
- known coronary artery disease
- Males over the age of 45 and females over the age of 55 with two or more risk factors for coronary artery disease. Risk factors are defined as hypercholesterolemia (total cholesterol greater than 240 mg/dL), hypertension (diastolic blood pressure greater than 90 mm Hg), 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 ACC/AHA has also published exercise testing guidelines [Gibbons et al. 2002]. The ACC/AHA 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 goes on to say the evidence is "less well established" (Class IIb) for the following groups:

1. Evaluation of persons with multiple risk factors as a guide to risk-reduction therapy with the risk factors essentially the same as the NFPA listed above.
2. Evaluation of 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 USDOT has also provided guidance for those seeking medical certification for a commercial drivers license. Their expert medical panel recommended exercise tolerance tests for asymptomatic "high risk" drivers [Blumenthal et al. 2007]. They define high risk drivers as those with any of the following:
- Diabetes mellitus
- Peripheral vascular disease
- Person above the age of 45 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 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, they 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."

Recommendation #2: Provide a comprehensive wellness program to complement the FD's physical fitness program.

Guidance for fire department wellness/fitness programs to reduce risk factors for cardiovascular disease and improve cardiovascular capacity is

Recommendations (cont.)

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 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].

The fire department already has a mandatory fitness program but NIOSH recommends a formal, structured wellness program to supplement the fitness program. This will help ensure all members receive the benefits of a well-structured health promotion program.

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Lieutenant Suffers Sudden Cardiac Death at Home following 24-hr Shift - Illinois

Investigator Information

This incident was investigated by the NIOSH Fire Fighter Fatality Investigation and Prevention Program, Cardiovascular Disease Component located 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

Pertinent Autopsy Findings

Heart Weight - 560 grams

Left Ventricular Hypertrophy (LVH)

Left ventricle wall 2.5 centimeters (cm) (normal by autopsy is 0.76–0.88 cm [Colucci and Braunwald 1997]; (normal by echocardiographic measurement is 0.6–1.1 cm) [Armstrong and Feigenbaum 2001]

Right Ventricle – 0.8 cm

Coronary arteries are patent without atherosclerotic changes

No evidence for a pulmonary embolus

Blood tests were negative for alcohol and other illicit drugs

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