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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 *March 17, 2006*

Fire Fighter Suffers Sudden Cardiac Death During Physical Fitness Training – New Jersey

SUMMARY

On May 31, 2005, a 58-year-old male career Fire Fighter (FF) began physical fitness training after eating lunch. After using the seated rowing machine, he suddenly collapsed. A nearby crew member saw the collapsed FF and notified crew members in the station and Dispatch, who sent an ambulance and a paramedic unit. Cardiopulmonary resuscitation (CPR) was performed, advanced life support (ALS) treatment was given, and the FF was transported to the local hospital's emergency department (ED). Despite ALS treatment in the ED, the FF died. The death certificate and the autopsy (both completed by the Medical Examiner) listed "calcific sclerosis of the aortic valve with aortic stenosis" as the cause of death, with "atherosclerotic coronary artery disease (CAD)" as a significant condition. The NIOSH investigator concluded that the FF's sudden cardiac death was due to his underlying aortic valve disease and his atherosclerotic CAD, possibly triggered by the physical exertion associated with physical fitness training.

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

Provide 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.

Provide fire fighters with medical evaluations and clearance to wear self-contained breathing apparatus (SCBA).

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.

Discontinue routine annual chest x-rays for hazardous materials technicians unless medically indicated.

Discontinue routine drug screens as part of the annual medical evaluation unless for cause.

INTRODUCTION & METHODS

On May 31, 2005, a 58-year-old male FF suffered sudden cardiac death while exercising at his fire station. NIOSH was notified of this fatality on June 1, 2005, by the United States Fire Administration. NIOSH contacted the affected fire department (FD) on June 8, 2005, to obtain further information, and on October 13, 2005, to initiate the investigation. On October 24, 2005, a Safety and Occupational Health Specialist from the NIOSH Fire Fighter Fatality Investigation Team traveled to New Jersey to conduct an on-site investigation of the incident.

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

- Fire Chief
- Deputy Fire Chief
- Crew members
- FF's wife

NIOSH personnel reviewed the following documents:

- FD incident report
- FD training records
- FD standard operating guidelines
- Ambulance report
- Hospital records
- Death certificate
- Autopsy report

INVESTIGATIVE RESULTS

On May 31, 2005, the FF (assigned to Ladder 3) arrived for duty at his fire station (Station 4) at about 0700 hours. Throughout the morning, the FF got his bunker gear ready, checked his self-contained breathing apparatus (SCBA) mask, performed housecleaning, and conducted a ladder raise with Ladder 3. The ladder raise involved driving the ladder truck outside the station, placing chocks (weighing about 7 pounds each) behind the rear wheels, extending the ladder jacks, placing jack plates (weighing about 15 pounds each) under the jacks, climbing onto the ladder turret (about 8 feet off the ground), and raising, rotating, and lowering the ladder. After the jacks were retracted, the FF replaced the jack plates and the wheel chocks in the apparatus compartment. He then checked the remainder of the equipment on Ladder 3. The crew then drove to another location to perform portable ladder training.

The FF and his Captain removed a 35-foot extension ladder weighing about 175 pounds, carried it about 20 yards, placed it against a wall, raised and lowered the ladder, then carried the ladder back to the apparatus and replaced the extension ladder onto Ladder 3. This operation took a total of about ten minutes. The crew drove back to Station 4 and performed classroom training on ladder operations and safety. The crew then ate lunch, rested for about an hour, and the FF read prior to exercising.

At about 1410 hours, the FF climbed the 30 steps to the second floor dorm/exercise area to begin his exercise program. His typical exercise routine consisted of using the rowing machine for about 10 minutes prior to power weight lifting. A crew member came out of the dorm area and saw the FF collapsed on the rowing machine. He called out to the FF, but the FF did not respond. The crew member assessed the FF and found him to be unresponsive, without a pulse, and not breathing; he began CPR. The crew member yelled for help, and other crew members responded. One crew member ran downstairs to retrieve the automated external defibrillator (AED) and the medical bag with oxygen equipment. Dispatch was notified (1425 hours) and an ambulance was sent.

The AED was attached to the FF, a shock was advised and delivered, and oxygen was administered via bag-valve-mask. The AED analyzed the FF's heart rhythm again, but no shock was advised, and CPR continued. The FF was placed onto a stretcher and carried down to the first floor. The ambulance arrived and the FF was re-assessed. Finding no pulse and respirations, CPR was continued. The FF's heart rhythm was analyzed again and no shock was advised. The FF was intubated (a breathing tube inserted in the trachea), an intravenous line was started, and cardiac resuscitation medications were administered. The FF was placed into the ambulance, which departed the scene en route to the hospital.

The ambulance arrived at the hospital ED at 1445 hours; at least 20 minutes after his cardiac arrest. Initial evaluation in the ED found the FF to be unresponsive, with CPR in progress and asystole (no heart beat) on the cardiac monitor. ALS measures continued for another 14 minutes with no improvement in the FF's condition. The FF was pronounced dead by the attending physician at 1459 hours and resuscitation measures were discontinued.

Medical Findings. The death certificate and the autopsy (both completed by the Medical Examiner) listed "calcific sclerosis of the aortic valve with aortic stenosis" as the cause of death and "atherosclerotic coronary artery disease" as a significant condition. Pertinent findings from the autopsy, performed on June 1, 2005, included the following:

- Calcific sclerosis of the aortic valve with aortic stenosis
- Enlarged heart (cardiomegaly): heart weighed 580 grams (g) (normal is <400 g)[1]
- Atherosclerotic CAD
  - Severe narrowing (75%) of the left anterior descending coronary artery
- No evidence of a pre-mortem pulmonary thromboemboli
- Negative drug and alcohol tests

Microscopic examinations revealed multiple small focal interstitial myocardial fibrosis.

Prior to his death, the FF had not been diagnosed with valvular heart disease. Despite numerous visits to his primary care provider (PCP) for musculoskeletal injuries and upper respiratory/sinus symptoms, it does not appear his heart was ever auscultated (e.g., no murmur was heard). The FF had three CAD risk factors: cigar smoking, hypertension (HTN), and obesity. At the time of his death, the FF was 73 inches tall and weighed 300 pounds, giving him a body mass index (BMI) of 39.5 kilograms per square meter (kg/m^2).[2] A BMI of 30.0 to 39.9 is considered obese.[2]

Electrocardiograms (EKGs) and various blood tests were performed by the FF's PCP, but NIOSH did not have access to those test findings at the time of this report. According to the FF's wife and crew members, he did not express any symptoms of cardiac-related problems during the days or months prior to his death.

DESCRIPTION OF THE FIRE DEPARTMENT

At the time of the NIOSH investigation, this career FD consisted of 252 uniformed personnel, served a population of 40,000 in a 16 square-mile area, and had six fire stations.

Employment and Training. The FD requires all fire fighter applicants to complete an application; be at least 18 years of age, but not over 35 years of age; possess a valid state driver's license; possess a high school diploma or equivalent; be a city resident; pass a written test; and pass a physical agility test prior to being ranked. When called for a job opening, the candidate must pass a background check and a pre-placement physical examination prior to being offered employment. The newly hired fire fighter must complete the 8-12 week City Fire Academy to become certified to the Fire Fighter 1 and 2 levels. Fire fighters work two 10-hour days from 0800 hours to 1800 hours, are off duty for 24 hours, work two 14-hour days from 1800 hours to 0800 hours, and are then off duty for 96 hours.

Career fire fighter hiring is governed by State civil service regulations. The FF was certified as a Fire Fighter 1 and a First Responder. He had 20 years of fire fighting experience.

Pre-placement Physical Examination. A pre-placement physical examination is required by this FD for all candidates. The contents of the examination are as follows:

- Complete medical history
- Physical examination
- Vital signs
- Complete blood count
- SMA-20 blood chemistry test
- Vision screening
- Audiogram
- Urine drug screen
- Urinalysis

- Spirometry
- Resting EKG
- Chest x-ray
- Tuberculosis PPD (purified protein derivative)

A City-contracted physician performs the medical examinations and forwards the clearance-for-duty decision to the FD medical records officer, who makes the final determination for clearance for duty.

Periodic Evaluations. Mandatory annual FD medical evaluations are offered to hazardous materials technicians and biannual medical evaluations are offered to hazardous materials support fire fighters. The contents of the examination are the same as those of the pre-placement physical examination. Medical clearance for SCBA use is required for hazardous materials technicians only. A different City-contracted physician performs these periodic medical evaluations and forwards the clearance-for-duty decision to the FD medical records officer, who makes the final determination.

An annual physical agility test is not required for members. There is a voluntary wellness/fitness program. Exercise equipment (strength and aerobic) is available in the fire stations. A return-to-duty medical clearance is required from the City-contracted physician for duty-related injuries and non-duty-related illnesses, if the illness prevents fire fighters from performing their duty for 10 days or more. The clearance is provided to the FD medical records officer, who reviews it and makes a final determination regarding return to work.

DISCUSSION

Aortic Stenosis (AS) and the Pathophysiology of Sudden Cardiac Death. Aortic stenosis (AS) is the narrowing of the aortic valve, which decreases the outflow of blood from the heart. It is the most common cardiac valve lesion in the United States and arises from congenital disorders (e.g., bicuspid valve) or from acquired conditions (e.g., rheumatic fever, HTN, endocarditis, connective tissue disorders, etc.).[3,4] Condition severity is determined by the valve surface area: mild (1.5-2.0 centimeters squared [cm^2]), moderate (1.0-1.5 cm^2), or severe (<1.0 cm^2).[5] Symptoms typically develop when the valve area shrinks to ≤1 cm^2. The most common symptoms are decreased exercise tolerance due to fatigue or dyspnea, exertional angina, and exertional light-headedness or syncope.[3,6,7]

The stenotic aortic valve eventually results in a compensatory left ventricular hypertrophy (LVH) which increases the heart muscle mass (myocardial) without an increase in the ventricular chamber.[3,6,8] This hypertrophy increases the myocardial oxygen demand and decreases the diastolic blood flow through the coronary arteries, creating an imbalance between myocardial oxygen supply and demand.[3]

Findings suggestive of AS include the presence of a characteristic heart murmur and EKG changes such as LVH or non-specific T-wave changes.[3,7,8] The diagnosis of AS is made by characteristic findings on echocardiography. Two additional tests are commonly performed for prognostic information; a gated blood pool scan to assess ventricular function and an exercise stress test (EST) to assess cardiac reserve.[3,8,9] The EST is contraindicated in symptomatic patients, but can be safely performed in asymptomatic patients under close physician observation.

Medical management includes prophylactic antibiotic treatment for endocarditis and advising the patient to limit strenuous, unmonitored exercise (due to the effect of LVH on coronary blood flow). Valve replacement is indicated in patients with severe disease.[3,6,9,10]

Disorders of the cardiac valves can adversely affect cardiac performance and place patients at risk for a cardiac emergency.[3,8] Natural history studies show that once classic symptoms develop, average survival decreases to 5 years with the onset of angina, 3 years after cardiac syncope, and 2 years after heart failure.[5,9] The incidence of sudden death increases from 1-2% annually among asymptomatic patients to 15-20% among symptomatic patients.[5,8-11]

Left Ventricular Hypertrophy. On autopsy, the FF had an enlarged heart and moderate LVH. LVH is a relatively common finding among individuals with long-standing HTN, a heart valve problem, or cardiac ischemia (reduced blood supply to the heart muscle).[1] The FF had no signs of cardiac ischemia, but did have aortic valve stenosis and HTN. Although LVH increases the risk for sudden cardiac death, the most likely reason for his sudden death was his AS, due to the degree of severity noted at autopsy.

Occupational Medical Standards for Structural Fire Fighters. 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*.[12] NFPA 1582 considers AS to be a Category B condition for candidates; acceptable if the condition is "mild," defined as an aortic valvular pressure gradient <20 millimeters of mercury (mmHg).[12] For members, NFPA 1582 considers aortic valve stenosis to potentially interfere with such essential job tasks as fire fighting tasks, climbing stairs while wearing full turnout gear, search and rescue, advancing hoselines, prolonged exertion, and two-in/two-out.[12] Medical records obtained by NIOSH suggested the FF never received an echocardiogram or any other test to measure his aortic valve pressure gradient, nor was a heart murmur identified. Since he had three CAD risk factors, NFPA 1582 would have recommended an EST. Perhaps results from this test would have triggered a more comprehensive cardiac evaluation and thus identify his underlying AS.

RECOMMENDATIONS

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

Recommendation #1: Provide 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 periodic medical evaluations and examinations for structural fire fighters can be found in NFPA 1582[12] and in the report of the International Association of Fire Fighters/International Association of Fire Chiefs (IAFF/IAFC) wellness/fitness initiative.[13] These medical examinations include auscultation of the heart. However, the FD is not legally required to follow any of these standards.

Applying NFPA 1582 involves economic issues. These economic concerns go beyond the costs of administering the medical program; they involve the personal and economic costs of dealing with the medical evaluation results. NFPA 1500, *Standard on Fire Department Occupational Safety and Health Program*, Chapters 8-7.1 and 8-7.2 address these issues.[14]

The physical evaluation could be conducted by the fire fighter's PCP or a City/County-contracted physician. If the evaluation is performed by the fire fighter's PCP, the results must be communicated to the City or County physician, who makes the final determination for clearance for duty.

Recommendation #2: Provide fire fighters with medical evaluations and clearance to wear SCBA.

The Occupational Safety and Health Administration (OSHA)'s Revised Respiratory Protection Standard requires employers to provide medical evaluations and clearance for employees using respiratory protection.[15] Such employees include fire fighters who utilize SCBA in the performance of their duties. These clearance evaluations are required for private industry employees and public employees in states operating OSHA-approved state plans. New Jersey is a state-plan state for public sector employees only; therefore, public sector employers are required to comply with OSHA standards.

Recommendation #3: Phase in a MANDATORY wellness/fitness program for fire fighters to reduce risk factors for CVD and improve cardiovascular capacity.

Physical inactivity is the most prevalent modifiable risk factor for CAD in the United States. NFPA 1500 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.[16] In 1997, the IAFF/IAFC published a comprehensive Fire Service Joint Labor Management Wellness/Fitness Initiative to improve fire fighter quality of life and maintain physical and mental capabilities of fire fighters. Ten FDs across the United States joined this effort to pool information about their physical fitness programs and create a practical fire service program. They produced a manual and a video which details elements of such a program.[13] Large-city negotiated programs can also be reviewed as potential models. Wellness programs have been shown to be cost effective, typically by reducing the number of work-related injuries and lost work days.[17-19] Similar cost savings have been reported by the wellness program at the Phoenix FD, where a 12-year commitment has resulted in a significant reduction in their disability pension costs.[20]

Recommendation #4: 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 FD members who engage in emergency operations to be annually evaluated and certified by the FD as meeting the physical performance requirements identified in paragraph 8-2.1.[14]

Recommendation #5: Discontinue routine annual chest x-rays for hazardous materials technicians unless medically indicated.

Regarding the content of the FD=s mandatory annual medial examination for hazardous materials technicians, the NFPA recommends chest x-rays every five years or as medically indicated.[12] Other organizations do not recommend routine asymptomatic screening chest x-rays to detect lung cancer. "The U.S. Preventive Services Task Force (USPSTF) concludes that the evidence is insufficient to recommend for or against screening asymptomatic persons for lung cancer with either low dose computerized tomography (LDCT), chest x-ray (CXR), sputum cytology, or a combination of these tests."[21] In our opinion, the annual chest x-rays performed on Hazmat members expose incumbents to unnecessary radiation and represent an unnecessary expense for the FD, and are not recommended by the OSHA Hazmat standard unless specifically indicated by the medical/occupational history.[22,23]

Recommendation #6: Discontinue routine drug screens as part of the annual medical evaluation unless for cause.

Impairment by drug or alcohol use can constitute an avoidable workplace hazard and that drug-free workplace programs can help improve worker safety and health. A comprehensive drug-free workforce approach includes five components—a policy, supervisor training, employee education, employee assistance, and drug testing. Such programs, especially when drug testing is included, must be reasonable and take into consideration employee rights to privacy. Although not required by OSHA, drug-free workplace programs are natural compliments to other initiatives that help ensure safe and healthy workplaces and add value to America's businesses and communities. [22,24] Testing for illegal drugs is not recommended as part of the annual medical evaluation per NFPA 1582.[12]

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