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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 *May 11, 2000*

Fire Fighter Dies in the Fire Station During the Night - New Jersey

SUMMARY

On June 4, 1999, a 47-year-old male Fire Fighter collapsed in the fire station after 8 hours on duty. Although the victim was dispatched to three calls during his shift, only one of the calls resulted in strenuous activity, and none of the responses involved exposure to hazardous chemicals capable of causing his collapse. After going to bed, the victim collapsed onto the floor and was found in cardiac arrest. Despite cardiopulmonary resuscitation (CPR) administered by fellow crew members and advanced life support (ALS) administered by ambulance service personnel and in the hospital's emergency department, the victim died. The death certificate, completed by the Medical Examiner, listed "hypertensive and atherosclerotic cardiovascular disease" as the immediate cause of death. Pertinent autopsy findings included "occlusive coronary artery disease with total stenosis of his left circumflex coronary artery, and atherosclerotic change of his left anterior descending coronary artery."

Other agencies have proposed a three-pronged strategy for reducing the risk of on-duty heart attacks and cardiac arrests among fire fighters. This strategy consists of (1) minimizing physical stress on fire fighters, (2) screening to identify and subsequently rehabilitate high-risk individuals, and (3) encouraging increased individual physical capacity. Issues relevant to this Fire Department include the following:

- ***Fire fighters should have annual medical evaluations to determine their medical ability to perform duties without presenting a significant risk to the safety and health of themselves or others. Exercise stress tests should be incorporated into the Fire Department's periodic medical evaluation program.***
- ***Phase in a mandatory wellness/fitness program for fire fighters to reduce risk factors for cardiovascular disease and improve cardiovascular capacity.***
- ***Review the department's policy regarding resuscitation equipment provided on fire apparatus and the training necessary to use the equipment.***

INTRODUCTION AND METHODS

On June 4, 1999, a 47-year-old male Fire Fighter went into cardiac arrest after going to bed for the night. Despite CPR administered by his fellow crew members and ALS administered by the ambulance crew and emergency department staff, the victim died. NIOSH was notified of this fatality on June 8, 1999, by the United States Fire Administration. On June 10, 1999, NIOSH contacted the affected Fire Department to initiate the investigation. On October 12, 1999, a Safety and Occupational Health Specialist and an Epidemiologist 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 with the

- Fire Director
- Fire Chief
- Crew members on duty with the victim
- Victim's wife

During the site visit NIOSH personnel reviewed the

- Victim's personnel file
- Emergency medical service (ambulance) report
- Death certificate
- Autopsy report
- Past medical records of the deceased
- Fire Department (FD) annual report for 1998

INVESTIGATIVE RESULTS

Incident. On June 3, 1999, the involved crew came on duty at 1800 hours. This was the second night tour on their shift schedule. After checking out the equipment, the crew prepared dinner, but the victim did not participate in the meal. He complained of having a severe toothache and took two Excedrin tablets. (He had complained of toothache pain throughout the day prior to coming to work). At 1900 hours the victim telephoned his wife, mentioning that he was tired and had a toothache. The crew was dispatched to three calls that evening: a false alarm, smoke in an apartment due to unattended cooking, and an alarm malfunction. After returning from the first call, the victim told his Captain that he felt bad and went to the bunkroom to lie down. Prior to responding to the second call, the victim had to manually raise the apparatus bay door because the automatic opener was inoperable. At the second call, the victim entered the smoky apartment in full bunker gear and SCBA, ventilated the apartment, and removed the burnt food from the kitchen stove. Upon returning to the station, the victim took two more Excedrin tablets and inhaled some oxygen (carried on Truck 12) because the toothache pain continued. The last call occurred at 0100 hours. The crew returned to their station by 0120 hours, completed the run report, and went to bed.

At about 0205 hours a noise was heard in the bunkroom. A Fire Fighter turned the bunkroom lights on, saw the victim on the floor, and yelled that a fire fighter was down. The victim was noted to be unresponsive, with no pulse or respirations, and CPR (chest compressions and mouth-to-mouth breathing) was begun.

An ambulance was requested at 0206 hours for a cardiac arrest. Ambulance 213, staffed with two Paramedics, and the Rescue Squad, staffed with two Emergency Medical Technicians with defibrillator certification (EMT-D) were dispatched immediately and arrived on scene at 0214 hours. Normal response time for this location would have been 2 minutes; however, both units were at a working fire 5 miles away.

The Rescue Squad took over patient care from the fire fighters and noted the victim to be unresponsive, with no pulse or respirations. A defibrillator was attached to the victim and a shockable heart rhythm was detected. Three shocks were administered with no positive change. The victim was loaded into the ambulance. A heart monitor was then attached to the victim and revealed that the victim's heart rhythm had reverted to asystole (no heart beat). Also, the victim's abdomen was noted to be distended. He was intubated and an intravenous (IV) line was started. Medications were administered consistent with ALS protocols while CPR continued. The ambulance departed the fire station at 0230 hours.

En route to the hospital, the victim's heart rhythm changed to ventricular fibrillation (V. Fib.). One shock was administered, and the rhythm reverted to asystole. The ambulance arrived at the hospital at 0237 hours. Emergency room records were not available to NIOSH investigators at the time of this report.

Medical Findings. The death certificate, completed by the Medical Examiner, listed "hypertensive and atherosclerotic cardiovascular disease" as the immediate cause of death. Since the Fire Fighter was not engaged in fire suppression activities at the time of his collapse, his carboxyhemoglobin level was not tested as an indicator of carbon monoxide poisoning. However, he had conducted interior operations in a smoky apartment fire approximately 1.5 hours earlier. In addition, it was reported that his fire station had an inoperable exhaust evacuation system, thereby potentially exposing the victim to carbon monoxide from apparatus exhaust emissions.[1]

Pertinent findings from the autopsy, performed by the medical examiner on June 4, 1999, are listed below:

- Coronary artery disease:
  - Occlusive coronary artery disease
  - Total stenosis of the left circumflex coronary artery
  - Atherosclerotic change of the left anterior descending coronary artery
- Biventricular hypertrophy and cardiomegaly
- Obesity

In 1988 the victim was diagnosed with high blood pressure (hypertension). Despite prescription medication for his hypertension, his blood pressure remained elevated. In addition to this risk factor for coronary artery disease (CAD), medical records indicated that the victim had other CAD risk factors, including advancing age (over 45 years old), male gender, smoking, and obesity/physical inactivity.

DESCRIPTION OF THE FIRE DEPARTMENT

At the time of the NIOSH investigation, the Fire Department consisted of 735 uniformed personnel and served a population of 275,000 residents (daytime population of 1 million) in a geographic area of 25 square miles. The department has 30 fire stations where fire fighters work the following shift: Day 1 and 2, on duty from 0800 to 1800 hours; Day 3 and 4, off duty; Day 5 and 6, on duty from 1800 to 0800; then off duty for 3 days. Each shift of an engine or ladder company is staffed with four personnel (an officer and three fire fighters). The rescue squad is a component of the Fire Department; however, the emergency medical service is a component of a local hospital.

Currently, the Fire Department has automated external defibrillators (AEDs) in use on the rescue squad, but they are not available on all fire apparatus.

In 1998, the department responded to 13,271 calls: 1,567 other fire calls, 1,070 structure fires, 799 vehicle fires, 2,340 malicious false alarms, 241 hazardous materials calls, and 7,512 other non-fire responses.

The day of the incident, the victim did not engage in heavy physical exertion. He complained of a toothache throughout the day. At 1800 hours he began his shift, the second night shift. The beginning of the shift was spent performing equipment checks, followed by dinner (which he did not attend) and the three responses. The victim did not report or show signs of discomfort, pain, or distress to his peers, with the exception of a toothache.

Training. The Fire Department requires all new fire fighters to complete the 6-week Fire Academy training to become certified at the Fire Fighter I level. Once recruit school is completed, the fire fighter is assigned to a fire station and receives daily training on each shift. The victim had 27 years of fire fighting experience and was a certified Fire Fighter I.

Preemployment/Preplacement Evaluations The department requires a preemployment/preplacement medical evaluation for all new hires, regardless of age. Components of this evaluation for all applicants include the following:

- A complete medical history
- Height, weight, and vital signs
- Physical examination
- Complete blood count with differential (CBC)
- Urinalysis
- Urine drug screen
- Breath alcohol test
- Syphilis test
- PPD skin tests (for tuberculosis)
- Chest X-ray
- Audiometry
- Pulmonary function test
- Visual acuity

These evaluations are performed by a contract physician hired by the City. Once this evaluation is complete, the physician makes a decision regarding medical clearance for fire fighting duties, and this is forwarded to the City's personnel director.

Periodic Evaluations. Annual medical evaluations are required by this department only for HAZMAT team members. The content of this evaluation includes the following:

- A complete medical history
- Height, weight, and vital signs
- Physical examination
- Hemoculture (if over 45 years old)
- "SMA24" (blood tests for various indicators of liver, kidney, and other metabolic functions)
- CBC
- Urinalysis
- Urine drug screen
- Blood lead level
- Zinc protoporphyrin level
- Chest X-ray
- Resting electrocardiogram (EKG)
- Audiometry
- PPD skin tests (for tuberculosis)
- Pulmonary function test
- Visual acuity

The victim had been cleared for fire fighting duties by the Fire Department subsequent to hernia surgery in 1996. According to records available to NIOSH, this evaluation did not include either a medical history or a resting EKG. The Department's medical screening program does not include exercise stress tests. If an employee is injured at work, the employee is evaluated and must be cleared for "return to work" by the fire fighter's private physician.

Although some stations have exercise (strength and aerobic) equipment, typically purchased by the fire fighters themselves, the department does not have a voluntary or required fitness/wellness program.

DISCUSSION

In the United States, coronary artery disease (atherosclerosis) is the most common risk factor for cardiac arrest and sudden cardiac death.[2] Risk factors for its development include increasing age (especially men over 45 and women over 55), male gender, family history of coronary artery disease, smoking, high blood pressure, high blood cholesterol, obesity/physical inactivity, and diabetes.[3] The victim had several of these risk factors (advancing age [over 45], male gender, smoking, high blood pressure, and obesity/physical inactivity).

The narrowing of the coronary arteries by atherosclerotic plaques occurs over many years, typically decades.[4] However, the growth of these plaques probably occurs in a nonlinear, often abrupt fashion.[5] 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.[6] This sudden blockage is primarily due to blood clots (thrombosis) forming on the top of atherosclerotic plaques.

Blood clots, or thrombus formation, in coronary arteries are initiated by disruption of atherosclerotic

plaques. Certain characteristics of the plaques (size, composition of the cap and core, presence of a local inflammatory process) predispose the plaque to disruption.[5] Disruption then occurs from biomechanical and hemodynamic forces, such as increased blood pressure, increased heart rate (HR), increased catecholamines, and shear forces, which occur during heavy exercise.[7,8] Fire fighting activities are strenuous and often require fire fighters to work at near maximal heart rates for long periods. The increase in heart rate has been shown to begin with responding to the initial alarm and persist through the course of fire suppression activities.[7-9] Epidemiologic studies have found that heavy physical exertion sometimes immediately precedes and triggers the onset of acute heart attacks.[10-13]

To reduce the risk of heart attacks and sudden cardiac arrest among fire fighters, the National Fire Protection Association (NFPA) has developed guidelines entitled *Medical Requirement for Fire Fighters*, otherwise known as Standard 1582.[14] They recommend, in addition to screening for risk factors for CAD, an exercise stress electrocardiogram (EKG), otherwise known as an exercise stress test (EST). The EST is used to screen individuals for CAD. Unfortunately, it has problems with both false negatives (inadequate sensitivity) and false positives (inadequate specificity), particularly for asymptomatic individuals (individuals without symptoms suggestive of angina).[15,16] This has led other expert groups to **not** recommend EST for asymptomatic individuals without risk factors for CAD.[17,18]

When these asymptomatic individuals **have** risk factors for CAD, however, recommendations vary by organization. The American College of Cardiology/American Heart Association (ACC/AHA) identifies two groups for EST: (1) men over the age of 40 with a history of cardiac disease (as a screening test prior to beginning a strenuous exercise program), and (2) men over age 40 with one or more risk factors.[17] They define five risk factors for CAD: hypercholesterolemia (total cholesterol greater than 240 mg/dL), hypertension (systolic greater than 140 mm Hg or diastolic greater than 90 mm Hg), smoking, diabetes, and family history of premature CAD (cardiac event in first-degree relative under 60 years old).[17] The U.S. Preventive Services Task Force (USPSTF) does not recommend EST for asymptomatic individuals, even those with risk factors for CAD; rather they recommend the diagnosis and treatment of modifiable risk factors (hypertension, high cholesterol, smoking, and diabetes).[18]

These recommendations change for individuals who might endanger public safety if an acute episode were experienced or for those who require high cardiovascular performance such as police and fire fighters. The National Fire Protection Association (NFPA) recommends EST for fire fighters without CAD risk factors at age 40 and for those with one or more risk factors at age 35.[14] NFPA considers risk factors to be family history of premature (less than age 55) cardiac event, hypertension, diabetes mellitus, cigarette smoking, and hypercholesterolemia (total cholesterol greater than 240 or HDL cholesterol less than 35).[14] The EST should then be performed on a periodic basis, at least once every two years.[14] The ACC/AHA indicates that data are insufficient data to justify periodic exercise testing in people involved in public safety; however, as mentioned previously, they recommend that men over age 40 with a history of cardiac disease be screened before beginning a strenuous exercise program.[17] Fire suppression activities involve strenuous physical activity; therefore, the ACC/AHA seem to be making a distinction between those already engaged in strenuous physical activity (conditioning), and those **beginning** a strenuous exercise program. The USPSTF indicates that evidence is insufficient to recommend screening middle-age and older men or women in the general population; however, "screening individuals in certain occupations (pilots, truck drivers, etc.) can be recommended on other

grounds, including the possible benefits to public safety."[18]

Thus, disagreement remains regarding whether asymptomatic fire fighters should have ESTs. Had an EST been performed in this fire fighter, his underlying CAD **may** have been identified and, if so, he could have been directed toward further evaluation and treatment.

RECOMMENDATIONS AND DISCUSSION

The following recommendations address health and safety generally. This list includes some preventive measures that have been recommended by other agencies to reduce the risk of on-the-job heart attacks and sudden cardiac arrest among fire fighters. These recommendations have not been evaluated by NIOSH but represent research presented in the literature or of consensus votes of Technical Committees of the National Fire Protection Association or labor/management groups within the fire service. In addition, they are presented in a logical programmatic order, and are not listed in a priority manner.

Recommendation #1: Fire fighters should have annual medical evaluations to determine their medical ability to perform duties without presenting a significant risk to the safety and health of themselves or others. EST should be part of this medical screening program.

Guidance regarding the content and scheduling of periodic medical examinations for fire fighters can be found in *NFPA 1582, Standard on Medical Requirements for Fire Fighters*[14], and in the report of the International Association of Fire Fighters/ International Association of Fire Chiefs wellness/ fitness initiative.[19] The department is not legally required to follow any of these standards. Nonetheless, we recommend the City and Union **negotiate** the content and frequency to be consistent with the above guidelines.

Annual/periodic medical evaluations should be conducted. EST should be incorporated into this periodic evaluation. The EST will undoubtably increase the costs associated with the medical evaluations. To some extent these costs could be offset by reducing the frequency of other tests included in the annual examinations (as discussed in the Discussion section). The EST could be conducted by the fire fighter's personal physician or the Department's contract physician. If the fire fighter's personal physician conducts the test, the results must be communicated to the City contract physician, who should be responsible for decisions regarding medical clearance for fire fighting duties.

In addition to providing guidance on the frequency and content of the medical evaluations, NFPA 1582 provides guidance on medical requirements for persons performing fire fighting tasks. Applying NFPA 1582 involves legal issues, so it should be carried out in a **confidential**, **nondiscriminatory** manner. Appendix D of NFPA 1582 provides guidance for fire department administrators regarding legal considerations in applying the standard.

Applying NFPA 1582 also 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*, addresses these issues in Chapter 8-7.1 and 8-7.2.[20]

The success of medical programs hinges on protecting the affected fire fighter. The department must (1) keep the medical records confidential, (2) provide alternate duty positions for fire fighters in rehabilitation programs, and (3) if the fire fighter is not medically qualified to return to active fire fighting duties, provide

permanent alternate duty positions or other supportive and/or compensated alternatives.

Recommendation #2: Phase in a mandatory wellness/fitness program for fire fighters to reduce risk factors for cardiovascular disease and improve cardiovascular capacity.

NFPA 1500 requires a wellness program that provides health promotion activities for preventing health problems and enhancing overall well-being.[20] In 1997, the International Association of Fire Fighters and the International Association of Fire Chiefs joined in 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 fire departments across the United States joined this effort to pool information about their physical fitness programs and to create a practical fire service program. They produced a manual and a video detailing elements of such a program.[19] The Fire Department and the Union should review these materials to identify applicable elements for their Department. Other large-city negotiated programs can also be reviewed as potential models.

Recommendation #3: Review the department's policy regarding resuscitation equipment provided on fire apparatus and the training necessary to use the equipment.

Fire fighters are frequently called to serve as "First Responders." Thus, fire fighters should be trained and equipped to handle various medical emergencies. The Fire Department should review their policies related to this issue, specifically resuscitation equipment [oxygen, pocket masks, oral airways and automated external defibrillators (AEDs)], and training in the use of this equipment and certification in CPR.[20-23]

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