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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 *October 22, 2001*

Fire Fighter Dies in Sleep During His Work Shift - Michigan

SUMMARY

On January 18, 2001, a 52-year-old male career Lieutenant did not report to his Engine company when it was dispatched to an early morning call (0118 hours). Upon returning to the station, his crew members found him unresponsive, not breathing, pulseless, and cool to the touch. Due to his cool skin, fire fighters determined he had been dead for at least 1 hour, and no resuscitation measures were initiated. The death certificate, completed by the Assistant Medical Examiner, listed "arteriosclerotic cardiovascular disease" as the immediate cause of death, and the autopsy found significant coronary artery disease.

The following recommendations address some general health and safety issues. 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 selected recommendations have not been evaluated by NIOSH, but represent published research or consensus votes of technical committees of the National Fire Protection Association (NFPA) or fire service labor/management groups.

- ***Provide <u>mandatory</u> annual medical evaluations to <u>ALL</u> fire fighters to determine their medical ability to perform duties without presenting a significant risk to the safety and health of themselves or others.***
- ***Phase in a mandatory wellness/fitness program for fire fighters to reduce risk factors for cardiovascular disease and improve cardiovascular capacity.***

Although unrelated to this fatality, the Fire Department should consider this additional recommendation:

- ***Provide adequate fire fighter staffing to ensure safe operating conditions.***

INTRODUCTION AND METHODS

On January 18, 2001, a 52-year-old male Lieutenant had sudden death sometime after retiring to bed for the night. Due to physical signs (cool skin) that were apparent when he was found, fire fighters determined he had been dead for over 1 hour and resuscitation measures were not initiated. NIOSH was notified of this fatality on February 8, 2001, by the United States Fire Administration. On April 30, 2001, NIOSH contacted the affected Fire Department to initiate the investigation. On May 22, 2001, a Safety and Occupational Health Specialist and a Visiting Scientist from the NIOSH Fire Fighter Fatality Investigation Team traveled to Michigan to conduct an on-site investigation of the incident.

Fire Fighter Dies in Sleep During His Work Shift - Michigan

During the investigation NIOSH personnel interviewed the following:

- Deputy Fire Commissioner
- Union Local President
- Crew members on duty with the victim
- Responding ambulance service personnel
- Victim's brother

During the site visit NIOSH personnel reviewed

- Fire Department policies and operating guidelines
- Fire Department training records
- The Fire Department annual report for 2000
- Emergency medical service (ambulance) incident report
- Fire Department physical examination protocols
- Death certificate
- Autopsy record
- Past medical records of the deceased

INVESTIGATIVE RESULTS

Incident. On January 17, 2001, the victim reported to work at Engine 5's quarters at approximately 0700 hours. During his shift, the Lieutenant was dispatched to five alarms: a fire alarm at a metal products business at 0727 hours, a fire alarm at a hospital at 1047 hours, a fire alarm at an apartment complex at 1102 hours, a car fire at 1420 hours, and a reported fire in a vacant building at 1458 hours. Only one response involved an actual fire: a car fire at 1420 hours. During this fire the Lieutenant assisted with opening the car hood to gain access to the engine compartment and complete extinguishment. Engine 5 returned to quarters at 1456 hours. At the other four emergency responses, no fires were found.

After the last response at 1458 hours, the crew remained in quarters for the remainder of the evening. The victim went to bed at approximately 2330 hours. At 0118 hours, a box alarm was transmitted for a fire in an office building. Engine 5 crew members arose and began to proceed from their bunkrooms to the engine bay. As they went down the hallway, one crew member noticed the victim's door was not yet opened, and he knocked on the door and yelled that they had a call. The crew members continued to the engine bay, staffed Engine 5, and awaited the victim for a short while. Thinking that he was sleeping, and the call was in their first-due district, they responded without him. Ladder 20 and Squad 2 also responded. On the scene, a small fire was found and quickly extinguished. Engine 5 was released early and returned to quarters at 0154 hours. Upon returning to quarters, the crew members noticed that the victim was still in his bunkroom. They entered his room, realized that something was wrong, and notified EMS 6 personnel (who shared quarters with Engine 5 and were in the station). The emergency medical technicians (EMTs) of EMS 6 checked the victim and found him to be unresponsive, pulseless, not breathing, and cool to the touch. A cardiac monitor attached to the victim revealed asystole (no heart beat). Further examination revealed the victim had been deceased for at least over 1 hour, and the Medical Examiner was notified. The Medical Examiner responded to the fire station, examined the victim, and pronounced him dead at 0245 hours.

Medical Findings. The death certificate, completed by the Medical Examiner, listed "arteriosclerotic cardiovascular disease" as the immediate cause of death. The autopsy listed the cause of death as "arteriosclerotic cardiovascular disease (heart attack)." "The heart was enlarged, its wall thickened with almost complete occlusion of one major vessel, making it prone to abnormal rhythms or 'heart attack' (sudden death)." A carboxyhemoglobin level was not checked. Pertinent findings from the autopsy, performed by the Medical Examiner, on January 18, 2001, included

- Significant occlusive coronary artery disease
  85% narrowing of the left main coronary artery

60% narrowing of the left anterior descending coronary artery
30% narrowing of the left circumflex
25% narrowing of the right coronary artery

- Enlarged heart
- Left ventricular hypertrophy
- Pulmonary congestion and edema

The Lieutenant had the following risk factors for coronary artery disease (CAD): advancing age (greater than 45 years old), male gender, hypertension, hypercholesterolemia, obesity, and lack of physical activity. There is no evidence that the victim was currently prescribed any medication. In October 2000, the victim suffered chest pains and sought medical treatment at a local hospital. Subsequent tests included a resting electrocardiogram (ECG), Thallium exercise stress test (EST), and an echocardiogram. His ECG and blood test (cardiac isoenzymes) were negative for a heart attack. Results of his thallium EST are listed below. He exercised for 12.5 minutes on a Bruce protocol, achieving 14.3 metabolic equivalents (METS), a double product of 22,560, and a normal blood pressure response to exercise. He achieved 83% of his maximum heart rate, stopping due to fatigue. He did not complain of chest pain during the test. His pre-exercise ECG showed normal sinus rhythm and non-specific ST changes. His post-exercise ECG showed 1mm horizontal ST segment depression and the same non-specific ST changes. His thallium images showed inhomogeneous distribution of tracer throughout the left ventricular myocardium with no reversible perfusion abnormalities. His left ventricular ejection fraction was estimated to be greater than 70%. Although the test was terminated prior to the Lieutenant achieving 85% of his maximum predicted heart rate, it found a normal functioning left ventricle and no evidence of exercise-induced ischemia.

According to his brother and crew members, the day of the incident, the victim did not report any symptoms suggestive of angina or heart attack.

DESCRIPTION OF THE FIRE DEPARTMENT

At the time of the NIOSH investigation, the Fire Department consisted of 1,248 uniformed personnel and served a population of 960,000 residents in a geographic area of 134 square miles. There are 42 fire stations. Fire fighters work the following shift: 0800-0800 hours, 24 hours on duty, 24 hours off duty, 24 hours on duty, 48 hours off duty. Monthly and semi-annually, fire fighters receive extra days off duty.

In 2000, the Department responded to 90,806 calls: 50,855 fire runs, 34,378 service runs, 2,965 rescue calls, 2,210 non-fire runs, and 398 hazardous materials calls. Engine 5 responded to 1,304 calls: 720 service runs, 528 fire runs, 32 rescue calls, 21 non-fire runs, and 3 hazardous materials calls. The day of the incident, the victim reported for work at approximately 0700, worked around the fire station, and responded to five calls.

Training. The Fire Department requires all new fire fighter applicants to pass a written exam, an agility test, a physical examination, and a background check prior to being hired. Newly hired fire fighters are then sent to the 14-week fire fighter training course at the City Fire Academy to become certified Fire Fighter I and II, Hazardous Materials (Hazmat) Awareness and Operations, Medical First Responder, and Height Rescue.

Recurrent training occurs daily on each shift. The State minimum requirement for fire fighter certification is the 230-hour Fire Fighter I and II course. The State requires annual Hazmat recertification. The victim was a certified Fire Fighter II and Hazmat

Operations. He had 28 years of fire fighting experience.

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

- A complete medical history
- Physical examination
- Blood tests: complete blood count with differential (CBC), SGOT/SGPT, cholesterol, and BUN/creatinine
- Resting electrocardiogram (ECG)
- Pulmonary function test (PFT)
- Audiogram
- Vision screen
- Chest X-ray
- Urinalysis
- Urine drug screen (10 Panel)
- Pregnancy test (females only)

Fire boat applicants and emergency mechanics receive an abbreviated preemployment/preplacement medical evaluation which includes

- A complete medical history
- Physical examination
- Urine drug screen
- Urinalysis
- Pregnancy test (females only)

These evaluations are performed by either a contracted clinic or the City physician. Once this evaluation is complete, the City physician makes a determination regarding medical clearance for fire fighting duties and forwards this decision to the City's personnel director.

Once confirmed (hired), the newly hired fire fighter receives a physical examination that includes

- An interval medical history
- Blood pressure check
- Physical examination that includes joints, chest, heart, ear/nose/throat, abdomen, and hernia

Periodic Evaluations. Annual medical clearance for fire fighting is required only for HazMat fire fighters. Other fire fighters receive a medical evaluation at promotion. Components of this evaluation include

- A complete medical history
- Physical examination
- Blood tests: complete blood count with differential (CBC), SGOT/SGPT, cholesterol, and BUN/creatinine
- Resting ECG
- Chest X-ray
- Urinalysis
- Urine drug screen (10 Panel)
- Pregnancy test (females only)

Annual SCBA medical clearance, however, is required for all fire fighters via a medical questionnaire, similar to that required by OSHA.[1] OSHA requires, in 29 CFR 1910.134, that a medical evaluation questionnaire be completed by an individual prior to being certified to wear a respirator, including an SCBA.

If employees are injured at work, or are ill and off work for 5 days or more, they are evaluated by their personal physician, who forwards his or her recommendation regarding "return to work" to the City physician, who makes the final determination. Exercise (strength and aerobic) equipment, located in the fire stations, is purchased by the fire fighters. The victim led an active lifestyle but did not participate in an exercise program. No wellness/fitness programs are in place for the Department. No health maintenance programs are available from the City.

The Lieutenant was last cleared for return to work by the City physician in 1997 following injuries sustained from a stairwell collapse during fire fighting operations. His last medical evaluation was conducted by his personal physician 3 months prior to his sudden cardiac death. This last evaluation included the thallium EST described earlier.

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 age over 45, male gender, family history of coronary artery disease, smoking, high blood pressure, high blood cholesterol, obesity, physical inactivity, and diabetes.[3,4] The victim had six of these risk factors (age over 45, male gender, high blood pressure, high blood cholesterol, obesity, and physical inactivity).

The narrowing of the coronary arteries by atherosclerotic plaques occurs over many years, typically decades.[5] However, the growth of these plaques probably occurs in a nonlinear, often abrupt fashion.[6] 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.[7] This sudden blockage is primarily due to blood clots (thrombosis) forming on the top of atherosclerotic plaques. Although the victim did not have a blood clot in one of his coronary arteries on autopsy (less than 50% of heart attack victims have them), he did have severe atherosclerotic disease, particularly in his left main coronary artery.

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.[7] Disruption then occurs from biomechanical and hemodynamic forces, such as increased blood pressure, increased heart rate, increased catecholamines, and shear forces, which occur during heavy exercise.[8,9]

Fire fighting is widely acknowledged to be one of the most physically demanding and hazardous of all civilian occupations.[10] 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.[11-13] Even when energy costs are moderate (as measured by oxygen consumption) and work is performed in a thermoneutral environment, heart rates may be high (over 170 beats per minute) owing to the insulative properties of the personal protective clothing.[14] Epidemiologic studies have found that heavy physical exertion sometimes immediately precedes and triggers the onset of acute heart attacks.[15-18] The victim wore full bunker gear during the five emergency responses he made. His activities ranged from walking on level ground to climbing several flights of stairs to gaining access to a car's engine compartment. This is considered a light-to-moderate level of physical exertion.[19]

The physical stress of responding to these alarms and his underlying atherosclerotic CAD contributed to this fire fighter's "probable" heart attack, subsequent cardiac arrest, and sudden death. The term "probable" is used because autopsy findings (thrombus formation), blood tests (cardiac isoenzymes), or an ECG findings are required to "confirm" a heart attack (myocardial infarction). The victim did not have a coronary artery thrombus on autopsy; he died prior to the cardiac isoenzymes becoming positive, and he had no heart beat to show the characteristic findings of a heart attack on his ECG.

To reduce the risk of heart attacks and sudden cardiac arrest among fire fighters, the NFPA has developed guidelines entitled "Standard on Medical Requirements for Fire Fighters and Information for Fire Department Physicians," otherwise known as NFPA 1582.[20] NFPA 1582 recommends a yearly physical evaluation to include a medical history, height, weight, blood pressure, and visual acuity test.[20] NFPA 1582 recommends a thorough examination to include vision testing, audiometry, pulmonary function testing, a complete blood count, urinalysis, and biochemical (blood) test battery be conducted on a periodic basis according to the age of the fire fighter (less than 30: every 3 years; 30-39: every 2 years; over 40 years: every year). NFPA 1582 also recommends fire fighters over the age of 35 with risk factors for CAD be screened for obstructive CAD by an EST.[20] Unfortunately, as this case demonstrates, the thallium EST is not a perfect test; it has a reported sensitivity and specificity of 95%.[21,22] Thus, despite failing to detect this individual's ischemic CAD, the FD should include EST in a mandatory periodic medical evaluation program.

RECOMMENDATIONS

The following recommendations address health and safety generally. It is unclear if any of these recommendations could have prevented the sudden cardiac arrest and subsequent death of this Lieutenant. 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 published research or consensus votes of technical committees of the NFPA or fire service labor/management groups.

Recommendation #1: Provide mandatory 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 fire fighters can be found in NFPA 1582, Standard on Medical Requirements for Fire Fighters and Information for Fire Department Physicians,[20] and in the report of the International Association of Fire Fighters/International Association of Fire Chiefs wellness/fitness initiative.[23] 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.

Specifically, according to NFPA 1582, "the use of chest X-rays in surveillance activities in the absence of significant exposures, symptoms, or medical findings has not been shown to reduce respiratory or other health impairment. Therefore, only pre-placement chest X-rays are recommended." The extra chest X-rays being conducted by the Fire Department expose incumbents to unnecessary radiation and represent an unnecessary expense for the Fire Department.

In addition to providing guidance on the frequency and content of the medical evaluation, NFPA 1582 provides guidance on medical requirements for persons performing fire fighting tasks. NFPA 1582 should be applied 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.[24]

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.

Physical inactivity, or lack of exercise, is the most prevalent modifiable risk factor for CAD in the United States. Additionally, physical inactivity is associated with other risk factors, namely obesity and diabetes.[25] 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.[24] In 1997, the International Association of Fire Fighters (IAFF) and the International Association of Fire Chiefs (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 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.[23] 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:Provide adequate fire fighter staffing to ensure safe operating conditions.

This finding did not contribute to this fatality, but was identified during the NIOSH investigation. NFPA 1500 recommends that "members operating in hazardous areas at emergency incidents shall operate in teams of two or more."[24] Reduced staffing causes those members on the scene to work harder and for longer periods of time. Engine and Ladder Companies should be staffed with four personnel at a minimum.

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