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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 *November 9, 2000*

Driver/Operator/Fire Fighter Suffers a Heart Attack and Dies While Supporting Fire Suppression Activities - New York

SUMMARY

On April 29, 1998, a 49-year-old male Driver/Operator/Fire Fighter responded to a fire in a high-rise apartment building. When the victim arrived on-scene he tested the hydrant, connected the pumper to the hydrant with a suction hose, and charged the pumper. He was wearing his uniform but no bunker gear or self contained breathing apparatus (SCBA). He then ran 464 feet to assist another Engine company hook up to a hydrant and stretch a supply line to the building. Hearing that his apparatus was interfering with a Ladder company's access to the fire building, he ran the 464 feet back to his Engine and then returned to assist the other Engine company. At that time, on-scene for a total of about 7 minutes, he notified the Battalion Chief (BC) / Incident Commander (IC) that he thought he was having a heart attack. Two on-scene Driver/Operator/Fire Fighters administered first aid and oxygen for 2 minutes, followed by treatment on-scene by ambulance paramedics for 11 minutes. During this time he was complaining of chest pain, but he was alert, oriented, and had stable vital signs. He was in stable condition during the two minutes in the ambulance, but upon arrival in the local hospital's emergency department, he had a cardiac arrest. Despite cardiopulmonary resuscitation (CPR) and advanced cardiac life support (ACLS) administered by hospital personnel, the victim died. The death certificate, completed by the Medical Examiner's Office listed "hypertensive and atherosclerotic cardiovascular disease" as the immediate cause of death. Pertinent autopsy results included marked atherosclerotic coronary artery disease (CAD), a small scar consistent with a remote (at least 3 months prior) heart attack (myocardial infarction), an enlarged heart (left ventricular hypertrophy), and no evidence of blood clots (thromboemboli) in his lungs. 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:

- ***Although there is not consensus on the use of exercise stress tests to detect CAD in asymptomatic fire firefighters, their use could be considered for fire fighters with multiple CAD risk factors and could be incorporated into the Fire Department's annual medical evaluation program.***

INTRODUCTION AND METHODS

On April 29, 1998, a 49-year-old male Driver/Operator/Fire Fighter complained of chest pain while supporting fire suppression activities at a high-rise apartment building. Despite treatment by on-scene

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. 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:

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Driver/Operator/Fire Fighter Suffers a Heart Attack and Dies While Supporting Fire Suppression Activities - New York

fire fighters (trained and certified as first responders) and ambulance paramedics, and CPR and ACLS administered by the hospital emergency department, the victim died. NIOSH was notified of this fatality on May 4, 1998, by the United States Fire Administration. On June 3, 2000, NIOSH contacted the affected Fire Department (FD) to initiate the investigation. On June 26, 2000, an occupational physician from the NIOSH Fire Fighter Fatality Investigation Team traveled to New York to conduct an onsite investigation of the incident.

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

- FD Executive Officer, Safety Command;
- FD Deputy Chief Medical Officer;
- Local Union Safety Representative;
- Company members on-duty with the victim;
- Victim's wife.

During the site-visit NIOSH personnel reviewed:

- FD investigative report of the fatality;
- FD policies and operating guidelines;
- FD training records of the victim;
- FD medical records of the victim;
- FD annual report for 1999;
- Emergency medical service (ambulance) report;
- Death certificate;
- Autopsy report;

INVESTIGATIVE RESULTS

Incident. On April 29, 1998, at 1340 hours, dispatch received a telephone alarm regarding a structural fire in a high rise apartment building. Engine Company 40, Ladder Company 25, and Battalion 11 were assigned to respond. Upon receipt of a second source at 1341 hours, Engine Company 39 (the victim's company), Engine Company 74, Ladder Company 131 (acting Ladder Company 24) were assigned. Engine Company 39 was second due, but traffic problems resulted in their arriving third at approximately 1350 hours. Seeing heavy fire on the 10th floor, the BC/IC transmitted a second alarm at 1351 hours.

Upon arrival of Engine 39 at the fire scene, the victim tested the hydrant, connected the pumper to the hydrant with a suction hose, and charged the pumper. He then ran approximately 464 feet with heavy tools to the front of the fire building to assist the Driver/Operator / Fire Fighter of Engine Company 74 hook up and stretch a 3½ inch supply hose to the fire building's "siamese" connection to the standpipe system. (All high-rise buildings in this jurisdiction are required to have these hookups allowing fire fighters access to water from nozzles on floors within the building.) At this time, Dispatch notified Ladder Company 25 that people were trapped on the roof of the fire building. The victim then heard, apparently via a walk-talkie, that his apparatus was blocking access to the front of the fire building for Ladder Company 3. He ran the 464 feet back to his apparatus, only to find his apparatus being repositioned by the Roofman of Ladder Company 3. He then returned to the front of the fire building to assist the Driver/Operator/Fire Fighter of Engine Company 74. At that time, approximately 1356 hours, he informed the BC/IC that he thought he was having a heart attack.

The BC/IC had the Driver/Operator/Fire Fighters of two companies (Engines 40, and 74) administer first aid and at 1357 hours radioed Dispatch for an ambulance. The Driver/Operator/Fire Fighters noted the victim's ashen skin color and that he was complaining of chest pain. They administered oxygen until the paramedics from a private ambulance company, already on-scene, arrived to treat the victim at approximately 1358 hours. Initial assessment of the victim found him alert, oriented to person, place, and time, complaining of chest pain radiating to his jaw and back. His skin was moist and pale, but his vital signs were stable (pulse 98, blood pressure 108/ palpable). An intravenous line was started, he was

given sublingual (under the tongue) nitroglycerin and an aspirin tablet to swallow, and a heart monitor was attached. The heart monitor was reported to show a regular sinus rhythm with a question of a nonlife threatening conduction abnormality (bundle branch block). The victim was stable during the two minute transport from the fire scene to the hospital, but upon arrival in the hospital's emergency room, he suffered a cardiac arrest. Despite CPR and ALS procedures administered by emergency room personnel for 48 minutes, he was pronounced dead at 1503 hours and resuscitation efforts were stopped.

The weather at 1400 hours was clear, with a temperature of 67 degrees Fahrenheit and 34% relative humidity.

Medical Findings. The death certificate, completed by the Medical Examiner, listed "hypertensive and atherosclerotic cardiovascular disease " as the immediate cause of death. Pertinent findings from the autopsy, performed by the Medical Examiner's Office on April 30, 1998, are listed below:

- Marked coronary artery atherosclerosis:
  Near occlusive mid-right CAD;
  Near occlusive proximal left anterior descending CAD;
- Small circumscribed area (0.5 by 1.2 by 1.0 centimeter) of subepicardial fibrosis in the mid-posterior left ventricular wall (non-transmural). This finding is consistent with a remote (at least three months) heart attack in the distribution of the right coronary artery lesion mentioned previously;
- Left ventricular hypertrophy
- No evidence of a blood clot (embolus) in the pulmonary arteries;
- His blood carboxyhemoglobin level was less than 3%, suggesting the victim was not exposed to excessive carbon monoxide levels.

The victim had four CAD risk factors including: age (>45 years), male gender, cigarette smoking, and mildly elevated blood cholesterol. Prior to his fatal heart attack, he did not complain of any pain suggestive of angina (heart pain due to reduced blood supply), and he maintained a fair amount of physical activity.

DESCRIPTION OF THE FIRE DEPARTMENT

At the time of the NIOSH investigation, the FD consisted of 10,997 Uniformed Fire Fighters and Fire Officers, 273 Fire Inspectors, 231 Fire Marshals, and 1,617 administrative support personnel serving a population between 8 and 9 million residents, in a geographic area of 536 square miles. There are over 300 fire stations and buildings. The emergency medical services have operated as a function of the FD since 1996. Fire fighters work the following shifts: Day 1 & 2: 9 a.m. to 6 p.m.; Day 3: off; Day 4&5: 6 p.m. to 9 a.m.; Day 6-8: off. In 1999, the FD made 949,803 fire runs to 447,148 fires, non-fires, and medical emergencies. The number of runs exceeds the number of incidents because more than one company can be dispatched to a single incident. The FD also made 1,264,602 EMS runs to 1,034,506 medical emergencies. Prior to the incident, the victim was on duty for 19 hours (he had switched a shift with another member of the company) and had responded to four alarms: one emergency, one fire on standby, one first responder, and one false alarm. The last alarm prior to the incident was the false alarm run, which that occurred 12 minutes earlier.

Training. The FD requires newly hired fire fighters to attend a 12-week training program at the Division of Training, after which they are certified fire fighters level I. This training includes certification as a first responder (which includes CPR). Driver / Operators are required to undergo an additional 2-week training

course. The victim was a certified as a Fire Fighter Level 1, Driver / Operator, and first responder, and had 27 years of fire fighting experience.

Pre-employment/Pre-placement Evaluations. The FD requires a pre-employment/pre-placement medical evaluation for all fire fighter candidates. Components of the pre-employment/pre-placement evaluation for all applicants include:

- A complete medical history and questionnaire
- Height, weight, and vital signs
- Physical examination
- Vision test
- Hearing test
- Blood tests: Complete blood count (CBC), chemistry panel (SMA 20) which includes a cholesterol and triglyceride measurement
- Urinalysis
- Urine drug test
- Spirometry (lung function tests)
- Resting electrocardiogram
- Chest X-ray
- Skin test for tuberculosis (PPD)
- Immunizations administered if proof of vaccination cannot be provided (hepatitis B, measles, mumps, & rubella (MMR), tetanus if a booster had not been given within the past 10 years)
- Fire Fighters assigned to waterways also are offered a hepatitis A vaccine.

These evaluations are performed by the FD Medical staff, who make a decision regarding medical clearance for fire fighting duties. New hires are also required to complete a physical fitness and strength test at the time of the medical evaluation. The aerobic test involves 3 minutes on a Stairmaster at 60 steps per minute with a 60-pound pack. An EKG is not taken, but the heart rate is recorded and must be less that 90% of maximum (220 minus age).

Periodic Evaluations

Since 1998, periodic medical evaluations have been required by this Department for **all** fire fighters. The goal has been to conduct these on an annual basis, but logistical problems have resulted in their being conducted approximately every 15 months. Components of this evaluation are identical to the pre-employment evaluation with three exceptions: the chest X-ray is required only every 3 years, 2) the drug screen is not required, 3) and the aerobic fitness test does not include a 60-pound pack and the passing heart rate is 85% of the fire fighter's maximum. The victim's last periodic medical evaluation, conducted by the FD in 1995, showed a medical history significant for a previous history of deep vein thrombosis documented by venogram for which he was intermittently taking a low dose (sub-therapeutic) of a blood thinner (anticoagulant), unremarkable physical examination, normal EKG, normal hearing and vision tests, and normal blood tests except for elevated cholesterol and triglyceride levels. He was cleared for SCBA use and unrestricted fire fighting duties. At the time of this evaluation in 1995, the aerobic fitness test (3 minutes on the Stairmaster) was not being conducted.

Medical Clearance, and Fitness/Wellness Programs

A fire fighter is injured at work must be evaluated and cleared for "return to work" by a physician in the FD's medical clinic. A fire fighter who misses work for one or more days because of a illness (work-related or not), must also be evaluated and cleared for "return to work" by the FD Medical staff.

All fire houses have exercise (strength and aerobic) equipment, typically purchased by the fire fighters themselves. There are voluntary smoking cessation and weight control programs, and a mandatory wellness/fitness program modeled after the International Association of Fire Fighters/International

Association of Fire Chiefs (IAFF/IAFC) wellness/ fitness initiative.[1]

DISCUSSION

In the United States, atherosclerotic CAD is the most common risk factor for cardiac arrest and sudden cardiac death.[2] Risk factors for its development include increasing age (> 45 years old), male gender, family history of CAD, smoking, high blood pressure, high blood cholesterol, obesity/physical inactivity, and diabetes.[3,4] The victim had four of these risk factors (age, male gender, smoking, and high cholesterol).

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 (thrombus) forming on the top of atherosclerotic plaques. Less than 50% of heart attack victims have a thrombus at autopsy. The victim did not have a thrombus noted at autopsy, but severe near occlusive atherosclerotic lesions in his left anterior descending artery and/or his right coronary artery and were probably responsible for his heart attack and sudden death.

Blood clots, or thrombus formation, in coronary arteries is 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.[6] 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.[4] 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.[8-10] Epidemiologic studies have found that heavy physical exertion sometimes immediately precedes and triggers the onset of acute heart attacks.[11-14] Maneuvering Engine 39 during a heavy traffic period would have been a stressful activity. In addition, running the 464 feet between where he parked his Engine and the front of the fire building three times within 7 minutes is considered heavy physical exertion.

The victim did have evidence of fibrosis consistent with an old (at least 3 months prior) heart attack on autopsy. Given the small size of this infarct and its location, it is not surprising that the victim did not report prior symptoms of chest pain, or that his EKG in 1995 was normal. Unfortunately, the first clinical manifestation of CAD is sudden cardiac death in 20 to 25% of cases.[1]

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 Requirements for Fire Fighters," otherwise known as NFPA 1582.[15] They recommend, in addition to screening for risk factors for CAD as provided by this department, 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).[16,17] This has led other expert groups to **not**

recommend EST for asymptomatic individuals without risk factors for CAD.[18, 19]

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 multiple risk factors.[18] They define five risk factors for CAD: hypercholesterolemia (total cholesterol > 240 mg/dL), hypertension (systolic >140 mm Hg or diastolic > 90 mm Hg), smoking, diabetes, and family history of premature CAD (cardiac event in 1st degree relative < 60 years old).[18] 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).[19]

These recommendations change for individuals who might endanger public safety if an acute episode were experienced, or 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.[15] 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).[15] The EST should then be performed on a periodic basis, at least once every 2 years.[15] The NFPA acknowledges that their recommendations are based on "no firm guidelines," but rely on a "reasonable approach" using expert consensus. The ACC/AHA indicates that there is 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.[18] 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 there is insufficient evidence 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."[19] The USPSTF did not specifically address whether asymptomatic fire fighters with CAD risk factors should undergo EST.

This FD was fully aware of the NFPA recommendations and the consensus opinion on which they are based. They have made an informed decision, taking into account the advantages and disadvantages of conducting EST in asymptomatic fire fighters regardless of the number of CAD risk factors present. Nonetheless, it is possible had this Driver/Operator/Fire Fighter had an EST his underlying CAD may have been identified and he could have been directed toward further evaluation and treatment.

RECOMMENDATIONS AND DISCUSSION

Other agencies have proposed a three-pronged strategy for reducing the risk of on-duty heart attacks and cardiac arrests 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. 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:

Recommendation #1: Although there is not consensus on the use of exercise stress tests to detect CAD in asymptomatic fire firefighters, their use could be considered for fire fighters with multiple CAD risk factors and could be incorporated into the Fire Department's annual medical evaluation program.

NFPA 1582, Standard on Medical Requirements for Fire Fighters, recommends at least biannual EST for fire fighters.[1,15] They recommend that these tests begin at age 35 for those with CAD risk factors, and at age 40 for those without CAD risk factors. These EST will undoubtedly increase the costs associated with the medical evaluations. To some extent these costs could be offset by reducing the frequency and content of other tests included in the current annual examination that are more protective than NFPA 1582. These include annual resting EKGs, annual spirometry, and periodic chest x-rays. Factors to consider would include at what age to start EST in asymptomatic fire fighters with CAD risk factors. Additional factors to consider include the number of CAD risk factors present and their severity. If the fire fighter's personal physician conducts the test, the results must be communicated to the FD's medical clinic, which is responsible for decisions regarding medical clearance for fire fighter duties.

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