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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 20, 2000*

Fire Fighter Dies as a Result of a Cardiac Arrest During a Trench Rescue—Georgia

SUMMARY

On May 14, 1999, a 47-year-old male fire fighter collapsed while assisting with command at a trench rescue. After being on scene for approximately 60 minutes, the fire fighter collapsed. Despite cardiopulmonary resuscitation (CPR) and advanced life support (ALS) administered by crew members, ambulance service personnel, and in the hospital's emergency department, the victim died. The death certificate, completed by the victim's personal physician, listed "acute myocardial infarction" (MI), commonly known as a heart attack, as the immediate cause of death. Pertinent autopsy results included the presence of a thrombosis (blood clot) in one of his coronary arteries, coronary atherosclerosis (plaque), and fibrosis consistent with remote (old) heart attacks (MIs).

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 individuals at higher risk; 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.***

- ***Phase in a mandatory wellness/fitness program for fire fighters to reduce risk factors for cardiovascular disease and improve cardiovascular capacity.***

INTRODUCTION & METHODS

On May 14, 1999, a 47-year-old male fire fighter collapsed at the scene of a trench rescue. Despite CPR administered by Emergency Medical Technicians (EMTs) and ALS administered by paramedics on scene, during transport to the emergency department, and in the emergency department, the victim died. NIOSH was notified of this fatality on May 17, 1999, by the United States Fire Administration. On November 19, 1999, NIOSH contacted the affected Fire Department to initiate the investigation. On December 15,1999, an Epidemiologist from the NIOSH Fire Fighter Fatality Investigation Team traveled to Georgia to conduct an on-site investigation of the incident.

During the investigation NIOSH personnel met with the

- Fire Chief of the affected department
- City Manager
- Fire Chief of a neighboring fire department
- Fire Department personnel involved in this incident
- Ambulance personnel responding to this incident
- Victim's wife

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:

http://www.cdc.gov/niosh/firehome.html

or call toll free **1-800-35-NIOSH**

During the site visit NIOSH personnel also reviewed

- Existing Fire Department investigative records, including incident reports, dispatch records, and photographs of the fire scene
- Fire Department policies and operating guidelines
- Fire Department training records
- The Fire Department annual report for 1999
- Past medical records of the deceased
- Autopsy results and death certificate of the deceased
- Ambulance dispatch records and response form
- The hospital's records of the resuscitation effort

INVESTIGATIVE RESULTS

Incident. On May 14, 1999, at 0941 hours, the volunteer Fire and Rescue Department was dispatched for two people trapped in a collapsed trench. A medic, traveling in an ambulance, arrived on scene at 0947 hours, followed by a rescue unit with four fire fighters at 0949 hours and a battalion chief and assistant chief in their private vehicles at 0950 hours. Upon arrival, the assistant chief took command of the scene at 0950 hours; one trapped individual had already been extricated. The first-in Engine, Engine 1, arrived on scene at 0956 hours. Rescue 10 arrived with four Fire Fighters at 0958 hours, and Engine 10, with three fire fighters, arrived at 1004 hours. Over the ensuing 4 hours approximately 200 emergency response personnel arrived on scene to assist with the rescue.

Vehicle staging was set up on the road, and arriving personnel were transported into the scene, located approximately ½ mile down a muddy dirt road, by four-wheel-drive vehicles. The command post was set up with line of sight to the trench. A rehabilitation area, set up adjacent to the command post, was equipped with an ambulance and staffed by first responders, EMTs, and paramedics. Personnel staging was established up an incline from the trench, with the trench rescue equipment between staging and the trench. At approximately 1030 hours, the fire fighter assisting with command was called to staging and the victim was called to the scene from Fire Department headquarters. The victim arrived on scene at approximately 1115 hours and reported to the command post. The victim was assigned to locate misplaced command boards, and he ran uphill from command to staging to try to find them. On the way back down to the command post, the victim stopped to help unload a pickup truck full of lumber being used for the rescue efforts. Upon returning to the command post, the victim assisted the scene commander with reestablishing the command boards and sat down in the front seat of the car at scene command. The victim, who had sinus discomfort and allergies, began to cough but had no other complaints. Moments later, the victim exited the car to speak with arriving personnel. At 1213 hours, while talking with these arriving individuals, the victim had a witnessed collapse.

An individual to whom the victim had been speaking was a First Responder, who immediately noted the victim to be unresponsive, with weak pulse and no respirations. The victim's head was moved to establish an airway for rescue breathing. When the head was moved, blood was noted in the mouth. Rescue breathing was initiated. The victim was checked again and found to be pulseless, and CPR (chest compressions and mouth-to-mouth resuscitation) was begun.

An ambulance was requested at 1214 hours for a cardiac arrest. Paramedics from Medic 1 at the rehabilitation area responded immediately and arrived at the victim at 1214 hours.

The paramedics took over patient care from the fire fighters. A defibrillator was attached to the victim and found a shockable heart rhythm. A total of four shocks were administered as ACLS was begun. The victim was loaded into the bed of a truck to be taken

to the ambulance at vehicle staging (the ambulance at rehab was remaining for the rescue efforts and reported that it was stuck in the muddy clay). After transfer from the truck to the ambulance, the endotracheal tube placement was checked, more medications were administered consistent with ACLS protocols, two more shocks were given, and CPR continued. The ambulance departed the scene at 1227 hours en route to the hospital. ACLS continued until the ambulance arrived at the hospital at 1237 hours. CPR and ACLS were continued in the emergency department before the victim was pronounced dead at 1245 hours and resuscitation efforts discontinued.

Medical Findings. The death certificate, completed by the victim's personal physician, listed "acute myocardial infarction" as the immediate cause of death and "hyperlipidemia" and "hypertension" as other significant conditions. Since the fire fighter was not engaged in fire suppression activities, his blood was not tested for carbon monoxide poisoning (carboxyhemoglobin levels).

The victim had many risk factors for coronary artery disease (CAD), including uncontrolled high blood pressure (hypertension), controlled high cholesterol (hyperlipidemia), diet-controlled, noninsulin-dependent diabetes, male gender, a current history of smoking, and physical inactivity. Prior to the rescue incident, the victim was not engaged in heavy physical exertion. He had complained of sinus problems throughout the day and the prior week. The victim did not report or show signs of discomfort, pain, or distress to his peers, with the exception of sinus problems.

Pertinent findings from the autopsy, performed by the medical examiner on May 14, 1999, are listed below:

- Coronary artery disease
  - Thrombosis in the right coronary artery
  - Segmental atherosclerosis in all three major branches with up to 50% luminal narrowing
  - Atherosclerotic change of the left anterior descending coronary artery with 75% occlusion
- Scarring of the heart (consistent with probable prior MIs)
- Myocardial hypertrophy (enlargement of the heart)
- Moderately severe chronic obstructive bronchopulmonary disease
- Moderately severe chronic bronchitis
- No evidence of a gastrointestinal bleed

DESCRIPTION OF THE FIRE DEPARTMENT

At the time of the NIOSH investigation, the Fire Department consisted of 52 active volunteer personnel and served a population of 30,000 residents in 36 square miles. The department has three fire stations. Each engine or ladder 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 separate organization. Currently, the Fire Department has automated external defibrillators (AEDs) in use on the rescue squad; however, they are not available on all fire apparatus.

In 1999, the department responded to 1,647 calls: 295 fire/explosion, two overpressure rupture, 811 rescue, 70 hazardous condition, 52 service, 171 good-intent, 239 false alarm, and 3 other situation calls.

Training. The Fire Department requires all new fire fighters to complete a 60-hour training course to become certified at the Basic Fire Fighter level. Once initial training is completed, the fire fighter attends weekly training sessions. The victim had more than 20 years of fire fighting experience and was a certified

Basic Fire Fighter, EMT, Industrial Fire Brigade Basic, and Advanced Rescuer.

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
- Blood work
- Urine drug screen
- Audiometry
- Visual exam

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 Fire Department.

Periodic Evaluations. The Department does not require periodic medical evaluations; however, if an employee is injured while responding to an incident, or has a nonfire-fighting-related injury resulting in lost work day(s), the fire fighter must be cleared for "return to work" by a personal physician.

Although weight-lifting equipment was purchased by the city and is available at Fire Headquarters, 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.[1] Risk factors for its development include increasing age, male gender, family history of coronary artery disease, smoking, high blood pressure, high blood cholesterol, obesity/physical inactivity, and diabetes.[2] The victim had many of these risk factors (male gender, smoking, high blood pressure, high cholesterol, diabetes, and physical inactivity).

The narrowing of the coronary arteries by atherosclerotic plaques occurs over many years, typically decades.[3] However, the growth of these plaques probably occurs in a nonlinear, often abrupt fashion.[4] 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.[5] This sudden blockage is primarily due to blood clots (thrombosis) forming on the top of atherosclerotic plaques. On autopsy, the victim had moderate atherosclerosis of all three coronary arteries and a thrombosis in his right coronary artery. These findings confirm that the victim suffered an acute MI.

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.[4] 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.[6,7] 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.[6-8] Epidemiologic studies have found that heavy physical exertion sometimes immediately precedes and triggers the onset of acute heart attacks.[9-12] Although this fire fighter was not engaged in fire suppression activities, he was performing physically stressful work (running uphill and unloading wood from a truck).

These factors, in addition to his underlying CAD, contributed to his heart attack, cardiac arrest, and sudden death.

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.[13] 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).[14, 15] This has led other expert groups to **not** recommend EST for asymptomatic individuals without risk factors for CAD.[16, 17]

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.[16] They define five risk factors for CAD: hypercholesterolemia (total cholesterol greater than 240 mg/dL), hypertension (systolic greater than140 mm Hg or diastolic greater than 90 mm Hg), smoking, diabetes, and family history of premature CAD (cardiac event in first-degree relative less than 60 years old).[16] 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).[17]

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.[13] 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).[13] The EST should then be performed on a periodic basis, at least once every 2 years.[13] The ACC/AHA indicates that data are insufficient 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.[16] 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."[17]

Thus, disagreement remains whether asymptomatic fire fighters should have ESTs. Had an EST been performed on 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.

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*.[13] 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. Applying this recommendation involves economic repercussions and may be particularly difficult for small, rural volunteer fire departments, such as the one involved in this incident, to implement.

To overcome the financial obstacle, this Fire Department could urge current members to get annual medical clearances from their private physicians. The recommended content of these evaluations is contained in NFPA 1582. Another option includes having the brief annual medical evaluations recommended by NFPA completed by the volunteer fire fighters (medical and occupational history) and by EMT/paramedics already on staff (vital signs, height, weight, and visual acuity), and this information could be shared with a community physician, perhaps volunteering his or her time, to review this data and provide medical clearance (or further evaluation, if needed). The more extensive periodic medical examinations could be performed by a private physician at the fire fighter's expense, provided by a physician volunteer, or paid for by the Fire Department. Sharing the financial responsibility for these evaluations among volunteers, the Fire Department, and willing physician volunteers should reduce the negative financial impact on recruiting and retaining needed volunteers.

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.[18] 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.

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INVESTIGATOR INFORMATION

This investigation was conducted by and the report written by Kristen Sexson, MPH, Epidemiologist. Ms. Sexson is with the NIOSH Fire Fighter Fatality Investigation and Prevention Program, Cardiovascular Disease Component, located in Cincinnati, Ohio.