



Death in the line of duty...

A Summary of a NIOSH fire fighter fatality investigation

December 6, 2000

Fire Fighter Dies at a Barn Fire - Ohio

SUMMARY

On December 13, 1999, a 50-year-old male Fire Fighter responded to a barn fire. After setting up a portable tank and unloading water into the tank, the victim proceeded to a tanker filling site, where he had a witnessed collapse. Despite cardiopulmonary resuscitation (CPR) and advanced life support (ALS) administered on the scene and at the hospital, the victim died. The death certificate, completed by the County Coroner after the autopsy was performed, listed "fatal cardiac arrhythmia" as the immediate cause of death due to "acute thrombotic occlusion of the right coronary artery" (heart attack), "80-90% narrowing of the left anterior descending coronary artery, and severe coronary atherosclerosis." Other significant conditions were listed as "hypertrophy and dilatation of the heart, acute marked congestion of the lungs, and splenomegaly."

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

- ***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.***
- ***Individuals with medical conditions that would present a significant risk to the safety and health of themselves or others should be precluded from fire-fighting activities.***

- ***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 and not part of the three-pronged prevention strategy, fire departments should ensure that all fire fighters have communication access at all times.***

INTRODUCTION AND METHODS

On December 13, 1999, a 50-year-old male Fire Fighter lost consciousness as he was directing traffic while filling a tanker truck. Despite oxygen and medication administered by the ambulance crew, and CPR and ALS in the emergency department, the victim died. NIOSH was notified of this fatality on December 15, 1999, by the United States Fire Administration. On January 14, 2000, NIOSH contacted the affected Fire Department to initiate the investigation. On January 31, 2000, an Epidemiologist from the NIOSH Fire Fighter Fatality Investigation Team traveled to Ohio to conduct an on-site investigation of the incident.

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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During the investigation NIOSH personnel met with and interviewed the

- Fire Chief
- Crew members on duty with the victim
- Responding ambulance service personnel
- Victim's wife

During the site visit NIOSH personnel reviewed the following:

- Existing Fire Department investigative records, including incident reports, and dispatch records
- Fire Department policies and operating guidelines
- Fire Department training records
- Fire Department annual report for 1999
- Emergency medical service (ambulance) report
- Hospital's records of the resuscitation effort
- Death certificate
- Autopsy results
- Past medical records of the deceased

INVESTIGATIVE RESULTS

Incident. On December 13, 1999, at 1815 hours, a volunteer Fire Department was dispatched on a mutual-aid call to a fully involved barn fire. An Engine arrived on the scene at 1824 hours with seven fire fighters, followed by Tanker #1 with two fire fighters at 1825 hours, a rescue unit with six fire fighters at 1826 hours, and a squad with two emergency medical service personnel (both Emergency Medical Technician's [EMTs]) at 1826 hours. A total of 31 fire fighters and EMS personnel responded either in fire department apparatus or by personal vehicle. Upon arrival, Tanker #1 and rescue personnel, including the victim, set up a portable water tank and suction lines and began to dump water from Tanker #1. This operation involved a moderate amount of physical exertion. After completing the dumping operation, the victim and one other fire fighter went to refill the tanker.

When Tanker #1 arrived at the hydrant, another Department's Tanker (Tanker #2) was attempting

to load water, so Tanker #1 parked in the street. Tanker #2 did not have the correct fittings to attach to the hydrant, so the victim and the Driver/Operator connected a 4-inch hose to the hydrant and Tanker #1. The victim got a flashlight from Tanker #1 to direct traffic around his Tanker, while the Driver/Operator helped Tanker #2 find proper hydrant fittings. The Driver/Operator from Tanker #1 was watching the water-level gauges when he saw the victim collapse at approximately 1848 hours. At first he thought the victim had tripped, but when no movement was apparent, he rushed to the victim and found him gasping for air. He took the coat off the victim while yelling for an ambulance for a fire fighter down. Due to a weak radio signal at the location of the hydrant, the Tanker #2 Driver/Operator could not transmit a radio message. The victim was still conscious and gasping for air, and Tanker #1's Driver/Operator tried to transmit a radio message from his Tanker. After several attempts, he received confirmation that his call for help had been heard, and an ambulance was dispatched at 1850 hours. While the Driver/Operators were attempting to call an ambulance, a Registered Nurse who lived nearby asked if anyone needed help. Soon after she arrived, the victim stopped breathing, and she immediately began rescue breathing (mouth to mouth). Shortly thereafter, the victim was rechecked and found to be pulseless; CPR (chest compressions and mouth-to-mouth resuscitation) was begun.

Emergency Medical Technicians (EMTs) and paramedics from Squad M-210 (the ambulance) and Rescue 206 with additional EMT's and a paramedic responded immediately from the fire area and arrived at the victim's location at 1856 hours. The EMTs took over patient care from the Fire Fighters and the Nurse. The victim was again noted to be without pulse and respirations, and CPR was continued. The ambulance crew was unable to intubate the victim due to large amounts of fluid in the upper airway. An automated external defibrillator (AED) was attached to the victim, and a shockable heart rhythm was



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identified. Two shocks were administered before the victim's heart rhythm degraded into asystole. CPR continued as the ambulance departed the scene at 1903 hours and arrived at the hospital at 1910 hours. CPR was continued per advanced cardiac life support (ACLS) protocol, although intubation was difficult due to copious amounts of gastric contents that required continuous suction. ACLS protocols were continued in the emergency department for 45 minutes until the victim was pronounced dead at 1955 hours.

Medical Findings. The death certificate, completed by the County Coroner after the autopsy was performed, listed "fatal cardiac arrhythmia" as the immediate cause of death due to "acute thrombotic occlusion of the right coronary artery, 80-90% narrowing of the left anterior descending coronary artery, and severe coronary atherosclerosis." Other significant conditions were listed as "hypertrophy and dilatation of the heart, acute marked congestion of the lungs, and splenomegaly." Pertinent findings from the autopsy, performed by the Medical Examiner on December 14, 1999, are listed below:

- Coronary artery disease
 - Severe coronary atherosclerosis
 - Complete acute thrombotic occlusion of the right coronary artery
 - Narrowing of the left coronary artery
 - Proximal and middle left anterior descending branch, near complete occlusion
 - Generalized moderate atherosclerosis
- Hypertrophy and dilatation of the heart
- Acute and chronic marked congestion of the lungs
- Splenomegaly

The victim's blood was not tested for carbon monoxide poisoning (carboxyhemoglobin levels) although the department requested this be done.

In 1989, the victim was diagnosed with high blood cholesterol (hypercholesterolemia) and high

triglycerides (hyper-triglyceridemia). Despite changes in his diet and efforts to begin an exercise program, his cholesterol level remained slightly elevated. Other coronary artery disease (CAD) risk factors included advancing age (greater than 45 years), male gender, smoking, and physical inactivity. In September 1998, the victim's private physician performed an exercise stress test (EST) for symptoms suggestive of angina (heart pain). The EST was interpreted as borderline positive after 9 minutes of exercise were completed and a 10 METS workload attained. The victim was prescribed nitroglycerin spray as needed and baby aspirin once a day. This medical history was not known by the Fire Department.

DESCRIPTION OF THE FIRE DEPARTMENT

At the time of the NIOSH investigation, the Volunteer Fire Department consisted of 43 uniformed personnel and served a population of 4,800 residents in a geographic area of 88 square miles. There is one fire station. The emergency medical service is part of the Fire Department.

In 1999, the Department responded to 631 calls: 473 EMS calls, 59 vehicle fires (including auto accidents), 39 structure fires, 21 alarms, 10 electric wires/transformer fires, 8 grass fires, 6 gas leaks, 5 false alarms, 2 bomb threats, 2 hazardous-materials calls, 1 tornado, 1 gas-processing plant, 1 grain bin, 1 wind damage, and 1 dumpster fire. The day of the incident, the victim had previously responded on one false-alarm call.

Training. The Fire Department requires all new fire fighters to complete the State Fire Academy courses to become certified at the Firefighter Level 1A before becoming a member. Subsequent training is provided at weekly meetings. The victim was a State-certified Fire Fighter- Level 1A, a certified EMT-1, and had 9 months of fire-fighting experience.



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Preemployment/Preplacement Evaluations. The Department requires a preemployment/preplacement medical evaluation for all new volunteers, regardless of age. Components of this evaluation are determined by the physician performing the evaluation. The exam typically includes

- A complete medical history
- Height, weight, and vital signs
- Physical examination
- Complete blood count (CBC)
- Blood lipid profile (total cholesterol, HDL cholesterol, triglycerides)
- PPD skin tests (for tuberculosis)
- Chest X-ray (if PPD is positive)
- Hepatitis test
- HIV test

These evaluations are performed by the individual's private physician. 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. Medical clearance for self-contained breathing apparatus (SCBA) use is not required.

Periodic Evaluations

Annual or periodic medical evaluations are not required. However, if employees are injured at work or away from work due to illness, they are evaluated and must be cleared for "return to work" by their private physician. The victim's last medical evaluation for illness was in May 1999, when he was cleared for fire-fighting duties. According to records available to NIOSH, this evaluation did not include an EST. The last EST, performed in 1998, was interpreted as borderline positive and was reported to the physician.

Although the fire station has exercise (strength and aerobic) equipment, currently purchased by the Fire Department, no formal (voluntary or required) fitness/wellness program exists.

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 several of these risk factors (advancing age, male gender, smoking, physical inactivity, and high blood cholesterol), and he had evidence of CAD on his EST.

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 an acute thrombotic lesion of his right 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.⁴ Disruption then occurs from biomechanical and hemodynamic forces, such as increased blood pressure, increased HR, increased catecholamines, and shear forces, which occur during heavy exercise.^{6,7} Firefighting activities are strenuous and often require fire fighters to work at near maximal heart rates for long periods.⁸ 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.⁹⁻¹¹ Epidemiologic studies have found that heavy physical exertion sometimes immediately precedes and triggers the onset of acute



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heart attacks.¹²⁻¹⁵ Although this Fire Fighter was not engaged in fire-suppression activities, he was performing moderately physically stressful work (setting up a portable tank, filling a tanker, directing traffic). Fire-fighting activities, in addition to his underlying CAD, may have 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 and Information for Fire Department Physicians," otherwise known as standard 1582.¹⁶ 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).¹⁷⁻²⁰ This has led other expert groups to not recommend EST for asymptomatic individuals without risk factors for CAD.²⁰⁻²¹

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.²⁰ 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 less than 60 years old).²⁰ 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).²¹

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 35.¹⁶ 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).¹⁶ The EST should then be performed on a periodic basis, at least once every 2 years.¹⁶ 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.²⁰ 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."²¹

The Department conducts preemployment/preplacement medical evaluations; however, the frequency and content differed from those recommended by the National Fire Protection Association (NFPA).¹⁶ NFPA recommends a yearly physical evaluation to include a medical history,



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height, weight, blood pressure, and visual acuity test. NFPA recommends a more thorough evaluation, 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 to 39, every 2 years; greater than 40 years, every year). The NFPA also recommends a vision test, audiometry, pulmonary function test, and EST for those 35 years old and above with known CAD risk factors, and 40 years old and above for those without CAD risk factors.¹⁶

In 2000, the NFPA updated 1582, Standard on Medical Requirements for Fire Fighters and Information for Fire Department Physicians.¹⁶ This voluntary industry standard specifies minimum medical requirements for candidates and current fire fighters. NFPA 1582 considers individuals with CAD (history of myocardial infarction, coronary artery bypass surgery, or coronary angioplasty) to be a “Category B Medical Condition.” A Category B Medical Condition is defined as “a medical condition that, based on its severity or degree, **could** (our emphasis) preclude a person from performing as a fire fighter in a training or emergency operational environment by presenting a significant risk to the safety and health of the person or others.” Appendix A of the Standard contains guidance for when to preclude a fire fighter with CAD from engaging in fire-fighting activities. Appendix A states that “persons at mildly increased risk for sudden incapacitation are acceptable for fire fighting. Mildly increased risk is defined by the presence of each of the following:

- Normal left ventricular ejection fraction
- Normal exercise tolerance, >10 metabolic equivalents (METS)
- Absence of exercise-induced ischemia by exercise testing
- Absence of exercise-induced complex ventricular arrhythmias

- Absence of hemodynamically significant stenosis on all major coronary arteries (≥ 70 percent lumen diameter narrowing), or successful myocardial revascularization.”

Based on this Fire Fighter’s EST in September 1998, he did not meet the third criterion and therefore should not have been cleared for fire-fighting duties without further treatment of his CAD.

RECOMMENDATIONS AND DISCUSSION

The following recommendations address health and safety generally. The first three recommendations are 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 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: Exercise stress tests should be incorporated into the Fire Department’s medical evaluation program.

NFPA 1582, Standard on Medical Requirements for Fire Fighter, and the International Association of Fire Fighters/International Association of Fire Chiefs wellness/fitness initiative both recommend at least biannual EST for fire fighters.^{16,22} 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 of other tests included in the current annual examination. The EST could be conducted by the fire fighter’s personal physician or



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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-fighter duties.

Recommendation #2: Individuals with medical conditions that would present a significant risk to the safety and health of themselves or others should be precluded from fire-fighting activities.

NFPA 1582, Standard on Medical Requirements for Fire Fighters and Information for Fire Department Physicians, lists medical conditions that **should** (Category A) or **could** (Category B) preclude individuals from performing fire-fighter activities.¹⁶ We recommend fire departments adopt these recommendations and share this standard (NFPA 1582) with physicians responsible for these decisions. Based on NFPA 1582 criteria, this victim's positive EST should have precluded him from unrestricted fire-fighter activities.

Recommendation #3: 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.²³ 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.²² 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 #4: Although unrelated to this fatality and not part of the three-pronged prevention strategy, fire departments should ensure that all fire fighters have communication access at all times.

NFPA 1201 requires that all communication system and mutual-aid network users have access to any and all frequencies used in the system to provide for effective communication. All fire fighters participating in emergency response activities should be provided with fully functioning communications devices and access.²⁴ It is unlikely that this recommendation could have prevented the sudden cardiac arrest and subsequent death of this fire fighter.

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