



Fire Fighter Suffers Sudden Cardiac Death After Repacking a Hose Load on a Fire Engine – New Jersey

SUMMARY

On February 4, 2004, a 52-year-old male volunteer Fire Fighter (FF) responded to two false alarms and performed station duties throughout the day, including repacking the speed lay (preconnected crosslay) on a fire engine. After he backed the engine into the fire station at approximately 1525 hours, he complained of not feeling well and having chest pain. The FF declined an offer to be driven to the nearby first aid building. While a crew member went to obtain some water for the FF, the FF suffered a witnessed collapse. Despite cardiopulmonary resuscitation (CPR) and advanced life support (ALS) performed by crew members, a police officer, ambulance service emergency medical technicians (EMTs) and paramedics, and hospital emergency department (ED) personnel, the FF died. The death certificate, completed by the Medical Examiner, listed “arteriosclerotic cardiovascular disease” (CAD) as the cause of death. No autopsy was performed. The NIOSH investigator concluded the physical stress of repacking the hose load and the FF’s underlying arteriosclerotic CAD contributed to his sudden cardiac death.

The following recommendations are preventive measures recommended by other fire service groups to reduce, among other things, the risk of on-the-job heart attacks and sudden cardiac arrest among fire fighters. These recommendations are listed in order of priority.

Provide pre-placement and 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.

Consider conducting exercise stress tests for male fire fighters over the age of 45 years with two or more risk factors for coronary artery disease.

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

Ensure that fire fighters are cleared for duty by a physician knowledgeable about the physical demands of fire fighting, the personal protective equipment used by fire fighters, and the various components of NFPA 1582, Standard on Comprehensive Occupational Medicine Program for Fire Departments.

Perform an annual physical performance (physical ability) evaluation to ensure fire fighters are physically capable of performing the essential job tasks of structural fire fighting.

Use a secondary (technological) test to confirm appropriate placement of the endotracheal (ET) tube during emergency intubations.

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. The program does not seek to determine fault or place blame on fire departments or individual fire fighters. 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 www.cdc.gov/niosh/firehome.html or call toll free 1-800-35-NIOSH



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Perform an autopsy on all on-duty fire fighter fatalities.

INTRODUCTION & METHODS

Incident. On February 4, 2004, a 52-year-old male FF suffered sudden cardiac death after being on duty for approximately 8 hours. Despite CPR and ALS performed by crew members, a police officer, ambulance service personnel, and hospital ED personnel, the FF died. NIOSH was notified of this fatality on March 15, 2004, by the United States Fire Administration. NIOSH contacted the affected Fire Department on March 24, 2004, to obtain further information, and on November 4, 2004, to initiate the investigation. On November 15, 2004, a Safety and Occupational Health Specialist from the NIOSH Fire Fighter Fatality Investigation and Prevention Team traveled to New Jersey to conduct an on-site investigation of the incident.

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

- Fire Chief
- FF's wife

During the site-visit NIOSH personnel reviewed the following documents:

- FD incident report
- FD training records
- Primary care physician (PCP) records
- Ambulance report
- Death certificate

INVESTIGATIVE RESULTS

On February 4, 2004, the FF was performing station duties when the involved fire department (FD) was

dispatched at 0738 hours to a report of a smoke odor. Engine 3-1, staffed with four fire fighters (including the FF) responded. Nothing was found and the engine returned to service at 0807 hours. At 0858 hours, the FD was dispatched for an activated pull station at a school. Again, Engine 3-1 responded, staffed with four fire fighters (including the FF). On scene, it was determined the pull station had been activated maliciously, there was no emergency, and Engine 3-1 returned to service at 0928 hours. During the return trip to the fire station, the speed lay (preconnected hose line) shifted in the hose bed. Once back at the fire station, the FF repacked the speed lay and performed other station duties (general clean up) throughout the day. At approximately 1525 hours, the FF backed Engine 3-1 into the fire station. After exiting the engine, he complained of not feeling well and of some chest pain. Crew Member 1 offered to drive the FF to the nearby first aid building, but the FF stated he would be fine. Crew Member 1 then went into the FD kitchen to obtain water for the FF. The FF suddenly collapsed in the presence of Crew Member 2.

Crew Member 2 called for assistance and notified Dispatch by radio of the need for an ambulance (1539 hours). Crew Member 2 retrieved oxygen equipment from Engine 3-1 and provided oxygen via bag-valve-mask to the FF. The FF was not responding to the oxygen and assessment revealed he was not breathing and had no pulse; CPR was begun. The ambulance, staffed with two paramedics, arrived on scene at 1543 hours. Patient assessment revealed the FF was unresponsive, not breathing, and without a pulse. CPR was in progress. A police officer arrived and an automated external defibrillator (AED) was retrieved from an engine. The AED was connected to the FF, his heart rhythm was analyzed, and shocks were advised. Over a 6 minute period, three shocks (defibrillation attempts) were administered prior to the paramedic (ALS) unit arrival at 1550 hours (11 minutes after his collapse).



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The paramedic connected a cardiac monitor to the FF, which revealed ventricular fibrillation (Vfib). An intravenous (IV) line was placed and the FF was intubated (a breathing tube inserted into the trachea). Lung sounds were confirmed with bilateral auscultation. Cardiac resuscitation medications were administered and two additional defibrillation attempts were made without change in the FF's status. The FF was placed into the ambulance, which departed the scene at 1604 hours en route to the hospital.

The ambulance arrived at the hospital ED at 1610 hours. Inside the ED, ALS resuscitation measures were continued including unsuccessful transcutaneous pacing. Despite CPR for 56 minutes and ALS for 45 minutes, there was no change in patient status. At 1635 hours, the attending physician pronounced the FF dead and resuscitation measures were discontinued.

Medical Findings. The death certificate, completed by the Medical Examiner, listed "arteriosclerotic cardiovascular disease" as the cause of death. No autopsy was performed.

At his last medical check up in February 2000, the FF weighed 252 pounds and was 73 inches tall, giving him a body mass index (BMI) of 33.2 kilograms per square meter (kg/m²). (A BMI 30 kg/m² and over is considered obese¹). The FF had a history of high blood pressure successfully treated with diet and exercise. He was never prescribed medications for his blood pressure and his last reading in February 2000 was normal. Available medical records did not indicate that blood tests had been performed to identify blood lipids (cholesterol) and glucose levels (for diabetes mellitus).

In December 1998, the FF had an episode of exertional epigastric discomfort. He was evaluated with an exercise stress test (EST). The FF

exercised for 9 minutes using the Bruce protocol² achieving a work level of 9 metabolic equivalents (METS) and a maximum heart rate of 162 beats per minute (bpm) (93% of the maximal age-predicted heart rate). His resting blood pressure was 140/94 mmHg, which rose to 200/94 mmHg during exercise. The test was discontinued upon completion of Stage III when 95% of calculated maximum heart rate was attained. His heart rate response to exertion was appropriate. His blood pressure response demonstrated an exaggerated systolic and paradoxical diastolic blood pressure response to exertion. He experienced no chest pain or shortness of breath with good exercise tolerance. No ventricular ectopy was seen during stress or recovery phase, but there was one isolated premature ventricular contraction. The EKG demonstrated no ST-T wave segment changes to suggest reversible ischemia. The FF's cardiologist concluded the EST to be negative, with no angina and a good exercise tolerance.

According to the FF's wife, the FF leisurely walked around a nearby lake a couple of times weekly but did not perform regular strenuous exercise. He had recently complained of chest pain when he became upset, but the pain did not radiate and would subside in a short time.

DESCRIPTION OF THE FIRE DEPARTMENT

At the time of the NIOSH investigation, this volunteer FD consisted of 60 uniformed personnel, served a population of 25,000 in a 9 square mile area, and had one fire station.

Training. The FD requires all fire fighter applicants to possess a valid state driver's license and pass a pre-placement physical examination, drug screening, and background check prior to being selected for membership. The member



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then begins a training program that includes the State Fire Fighter 1 (FF1) program conducted at local fire academies and an in-house training program. The fire academy also requires a physical ability test and fitness training as part of the curriculum. The member is on probation until the FF1 program is completed. The minimum State requirement for full fire fighter certification is Fire Fighter 1.

The FF was certified as a Fire Fighter and in Hazardous Materials Level 2. He had 31 years of fire fighting experience and was a former fire commissioner and police officer.

Pre-placement Physical Examination. A pre-placement physical examination is required by this FD for all applicants. The contents of the examination are as follows:

- Complete medical history
- Physical examination
- Vital signs
- Vision screening
- Audiogram
- Urine dipstick
- Urinalysis

Periodic Medical Evaluations. No periodic medical evaluations, physical agility test, or wellness/fitness programs are required by this FD for budgetary reasons and concerns that such requirements would hamper recruitment efforts. A “return-to-duty” medical clearance is required for illnesses and injuries that prevent fire fighters from performing their duty. The member’s primary care physician provides the clearance, which is forwarded to the Fire Chief, who makes the final determination for return-to-duty. Annual self-contained breathing apparatus

fit tests, including spirometry, are required.

DISCUSSION

Coronary Artery Disease (CAD) and the Pathophysiology of Sudden Cardiac Death.

In the United States, coronary artery disease (atherosclerosis) is the most common risk factor for cardiac arrest and sudden cardiac death.³ Risk factors for CAD development include age over 45, male gender, family history of coronary artery disease, smoking, high blood pressure (systolic >140 millimeters of mercury [mmHg] or diastolic > 90 mmHg), high blood cholesterol (total cholesterol > 240 milligrams per deciliter [mg/dL]), obesity/physical inactivity, and diabetes.^{4,5} The FF had three of these risk factors (age over 45, male gender, and obesity) and possibly a fourth (high blood pressure).

The narrowing of the coronary arteries by atherosclerotic plaques occurs over many years, typically decades.⁶ However, the growth of these plaques probably occurs in a nonlinear, often abrupt fashion.⁷ 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.⁸ This sudden blockage is primarily due to blood clots (thrombosis) forming on the top of atherosclerotic plaques. The 15 minutes of chest pain the FF experienced before collapsing indicate that he probably suffered a heart attack. The term “probably” is used because autopsy findings (thrombus formation), blood tests (cardiac isoenzymes), or ECG findings are required to confirm a heart attack (myocardial infarction [MI]). No autopsy was performed, the FF died prior to the cardiac isoenzymes becoming positive, and the FF did not have a heart rhythm on which to conduct an EKG.



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Firefighting is widely acknowledged to be one of the most physically demanding and hazardous of all civilian occupations.⁹ Firefighting 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.¹⁰⁻¹² 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.¹³ Epidemiologic studies have found that heavy physical exertion sometimes immediately precedes and triggers the onset of acute heart attacks.¹⁴⁻¹⁷ The FF had just reloaded the pre-connected hose lay. This is considered a moderate level of physical exertion.^{18,19} The physical stress of repacking the hose lay and his underlying atherosclerotic CAD contributed to this fire fighter's cardiac arrest and sudden death.

Occupational Medical Standards for Structural Fire Fighters. To reduce the risk of sudden cardiac arrest or other incapacitating medical conditions among fire fighters, the National Fire Protection Association (NFPA) has developed the NFPA 1582 guideline, *Standard on Comprehensive Occupational Medicine Program for Fire Departments.*²⁰

Use of Exercise Stress Tests to Screen for CAD. In addition to screening for CAD risk factors, NFPA 1582 recommends an EST for some asymptomatic (i.e., no symptoms of angina) fire fighters. Conducting EST on asymptomatic individuals is somewhat controversial. NFPA 1582 recommends, not as a part of the requirements but for informational purposes only, that all fire fighters with two or more risk factors for CAD to take an EST. The Standard lists

the following criteria for CAD risk factors: hypercholesterolemia (total cholesterol greater than 240 mg/dL), hypertension (systolic greater than 140 mm Hg or diastolic greater than 90 mm Hg), smoking, diabetes, or family history of premature CAD (cardiac event in first degree relative less than 60 years old).²⁰

The American College of Cardiology/American Heart Association (ACC/AHA) states that the evidence to conduct EST in asymptomatic individuals with diabetes mellitus is "Class IIa: there is conflicting evidence and/or a divergence of opinion about the usefulness/efficacy but the weight of the evidence/opinion is in favor."²¹ The AHA/ACC goes on to say the evidence is "less well established" (Class IIb) for the following groups:

1. Evaluation of persons with multiple risk factors as a guide to risk-reduction therapy with the risk factors essentially the same as the NFPA standard listed above
2. Evaluation of asymptomatic men older than 45 years, and women older than 55 years who are sedentary and plan to start vigorous exercise
3. Evaluation of asymptomatic men older than 45 years, and women older than 55 years who are involved in occupations in which impairment might jeopardize public safety (e.g., fire fighters)
4. Evaluation of asymptomatic men older than 45 years, and women older than 55 years who are at high risk for CAD due to other diseases (e.g., peripheral vascular disease and chronic renal failure)

The U. S. Department of Transportation (DOT) also addresses the issue of EST. To obtain



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medical certification for a commercial driver's license, DOT recommends EST for drivers over the age of 45 with more than two CAD risk factors.²² The U.S. Preventive Services Task Force (USPSTF), however 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).²³ The USPSTF indicates that there is insufficient evidence to recommend screening middle age and older men or women in the general population but notes that "screening individuals in certain occupations (pilots, truck drivers, etc.) can be recommended on other grounds, including the possible benefits to public safety."

Since the FF had only one CAD risk factor (hypertension) for EST determination, the performance of an EST would not have been recommended by any of the above organizations. While a mandatory comprehensive wellness/fitness program, including weight reduction, dietary education, and exercise would have benefited this fire fighter, it is unclear if that alone would have prevented this FF's death at this time.

RECOMMENDATIONS

The following recommendations are preventive measures recommended by other fire service groups to reduce, among other things, the risk of on-the-job heart attacks and sudden cardiac arrest among fire fighters. These recommendations are listed in order of priority.

Recommendation #1: Provide pre-placement and 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 pre-placement and periodic medical evaluations and examinations for structural fire fighters can be found in NFPA 1582, *Standard on Comprehensive Occupational Medical Program for Fire Departments*,²⁰ in the report of the International Association of Fire Fighters/ International Association of Fire Chiefs (IAFF/ IAFC) wellness/fitness initiative,²⁴ and the National Volunteer Fire Council (NVFC) Health and Wellness Guide.²⁵ The FD is not legally required to follow any of these standards.

Applying NFPA 1582 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*, Chapter 8-7.1 and 8-7.226 and the *NVFC Health and Wellness Guide*²⁵ address these issues.

The physical evaluation could be conducted by the fire fighter's primary care physician or a City/ County-contracted physician. If the evaluation is performed by the fire fighter's primary care physician, the results must be communicated to the City or County physician, who should be responsible for decisions regarding medical clearance for fire fighting duties.

Recommendation #2: Consider conducting exercise stress tests for male fire fighters over the age of 45 years with two or more risk factors for coronary artery disease.

NFPA 1582 and the IAFF/IAFC wellness/fitness initiative recommend EST for fire fighters with two or more CAD risk factors.^{20, 24} The AHA states EST may be indicated for individuals with two or



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more risk factors for CAD who are over 45 years of age.²¹ The EST could be conducted by the fire fighter's personal physician or the City/County contract physician. If the fire fighter's personal physician conducts the test, the results must be communicated to the City/County physician, who should be responsible for decisions regarding medical clearance for fire fighting duties.

The American College of Cardiology/American Heart Association (ACC/AHA) recommends conducting EST with increasing speed AND **grade** terminating when symptoms appear, rather than an arbitrary percentage of predicted maximal heart rate.²⁷ Exercise testing should be supervised by an appropriately trained physician. Symptom-limited testing with the Borg scale as an aid is very important when the test is used to assess functional capacity.

Recommendation #3: Phase in a mandatory wellness/fitness program for fire fighters to reduce risk factors for cardiovascular disease and improve cardiovascular capacity.

Physical inactivity is the most prevalent modifiable risk factor for CAD in the United States. Additionally, physical inactivity, or lack of exercise, is associated with other risk factors, namely obesity and diabetes.²⁸ 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.²⁶ NFPA 1583, *Standard on Health-Related Fitness Programs for Fire Fighters*, provides the minimum requirements for a health-related fitness program.²⁹

In 1997, the IAFF and the 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.²⁴ Large-city negotiated programs can also be reviewed as potential models. Wellness programs have been shown to be cost effective, typically by reducing the number of work-related injuries and lost work days.³⁰⁻³² A similar cost savings has been reported by the wellness program at the Phoenix Fire Department, where a 12-year commitment has resulted in a significant reduction in their disability pension costs.³³ The NVFC Health and Wellness Guide addresses wellness/fitness programs as they relate to volunteer fire departments.²⁵

Recommendation #4: Ensure that fire fighters are cleared for duty by a physician knowledgeable about the physical demands of fire fighting, the personal protective equipment used by fire fighters, and the various components of NFPA 1582, Standard on Comprehensive Occupational Medicine Program for Fire Departments.

Physicians providing input regarding medical clearance for fire fighting duties should be knowledgeable about the physical demands of fire fighting and should recognize that fire fighters frequently respond to incidents in environments that are immediately dangerous to life and health (IDLH). They should also be familiar with a FF's personal protective equipment and the consensus guidelines published by NFPA 1582, *Standard on Comprehensive Occupational Medicine Program for Fire Departments*.²⁰ To ensure physicians are aware of these guidelines, we recommend that the FD, or the FF, provide personal physicians with a copy of NFPA 1582.



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We also recommend the FD retain a “Fire Department Physician” to critically review all medical clearances. This decision requires knowledge not only of the medical condition, but also of the fire fighter’s job duties. Personal physicians may not be familiar with an employee’s job duties, or guidance documents, such as NFPA 1582. In addition, they may consider themselves patient advocates and dismiss the potential public health impact of public safety officials who may be suddenly incapacitated.

Recommendation #5: Perform an annual physical performance (physical ability) evaluation to ensure fire fighters are physically capable of performing the essential job tasks of structural fire fighting.

NFPA 1500 requires fire department members who engage in emergency operations to be annually evaluated and certified by the fire department as meeting the physical performance requirements identified in paragraph 8-2.1.²⁶

Recommendation #6: Use a secondary (technological) test to confirm appropriate placement of the endotracheal (ET) tube during emergency intubations.

To reduce the risk of improper intubation, the American Heart Association and the International Liaison Committee on Resuscitation published recommendations in the Guidelines 2000 for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care.³⁴ These guidelines recommend confirming tube placement by primary and secondary methods. Primary confirmation is the 5-point auscultation: left and right anterior chest, left and right midaxillary, and over the stomach. Secondary confirmation requires a technology test, either an end-tidal carbon dioxide

detector or an esophageal detector device. In this incident, the FF had bilateral breath sounds confirmed by auscultation, however, according to records obtained by the NIOSH investigator, secondary confirmation was not performed.

Recommendation #7: Perform an autopsy on all on-duty fire fighter fatalities.

In 1995, the United States Fire Administration (USFA) published the Firefighter Autopsy Protocol.³⁵ With this publication the USFA hopes to provide “a more thorough documentation of the causes of firefighter deaths for three purposes:

1. to advance the analysis of the causes of firefighter deaths to aid in the development of improved firefighter health and safety equipment, procedures, and standards;
2. to help determine eligibility for death benefits under the Federal government’s Public Safety Officer Benefits Program, as well as state and local programs; and
3. to address an increasing interest in the study of deaths that could be related to occupational illnesses among firefighters, both active and retired.”

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INVESTIGATOR INFORMATION

This investigation was conducted by and the report written by:

Tommy N. Baldwin, MS
Safety and Occupational Health Specialist

Mr. Baldwin, a National Association of Fire Investigators (NAFI) Certified Fire and Explosion Investigator, an International Fire Service Accreditation Congress (IFSAC) Certified Fire Officer I, and a Kentucky Certified Fire Fighter and Emergency Medical Technician (EMT), is with the NIOSH Fire Fighter Fatality Investigation and Prevention Program, Cardiovascular Disease Component located in Cincinnati, Ohio.

Department of Health and Human Services

Centers for Disease Control and Prevention
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