



## Volunteer Fire Fighter Suffers Cardiac Arrest While Battling a Structure Fire – New York

### SUMMARY

On May 13, 2004, a 42 year-old male volunteer Fire Fighter (FF) suffered a cardiac arrest while battling a residential structure fire. He had engaged in hose pulling and exterior fire suppression activities for approximately 15 minutes. Shortly thereafter, fellow fire fighters reported that he “did not look right.” On-scene Emergency Medical Service (EMS) personnel were summoned to assist the FF, only to find him at the back of the rescue truck in cardiac arrest.

Cardiopulmonary resuscitation (CPR) was immediately begun. Once the on-scene ambulance relocated to the FF’s vicinity, advanced life support (ALS) protocols were initiated and continued en route to the hospital. His condition failed to improve. Despite over 30 minutes of resuscitative efforts at the scene, in the ambulance, and at the hospital, the FF died.

The death certificate completed by the medical examiner listed the immediate cause of death as an acute myocardial infarction (heart attack) with physical exertion in a hot, humid environment listed as a contributing cause. An autopsy was not performed. NIOSH investigators concluded that the FF’s heavy physical exertion, coupled with his probable underlying coronary artery disease (CAD) triggered his sudden cardiac death.

It is unlikely the following recommendations could have prevented the FF’s death. Nonetheless, the NIOSH investigators offer these recommendations to reduce the risk of on-the-job heart attacks and sudden cardiac arrest among fire fighters.

- *Expand the current annual medical evaluation requirement to include Driver/Operators.*
- *Consider conducting exercise stress tests (ESTs) for FFs with two or more coronary artery disease (CAD) risk factors.*
- *Ensure FFs are cleared for duty by a physician knowledgeable about the physical demands of fire fighting and the various components of NFPA 1582, and ensure that the results of these exams are discussed with the FFs.*
- *Phase in a mandatory wellness/fitness program for FFs to reduce risk factors for cardiovascular disease and improve cardiovascular capacity.*
- *Conduct pre-placement and annual physical performance (physical ability) evaluations on FFs to ensure that they are physically capable of performing the essential job functions of structural fire fighting.*

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](http://www.cdc.gov/niosh/firehome.html) or call toll free 1-800-35-NIOSH



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- *Strengthen the FD's current rehabilitation program.*
  - *Provide annual bloodborne pathogen (BBP) training to members likely to come into contact with blood while serving as a first responder.*
  - *Perform an autopsy on all on-duty fire fighter fatalities.*
- ED records
  - Death certificate
  - Medical records
  - FD Standard Operating Policies and Procedures
  - FD annual report
  - FD training records

## **INTRODUCTION AND METHODS**

On May 13, 2004, a 42 year-old male volunteer FF suffered a cardiac arrest while battling a residential structure fire. Despite the administration of CPR and ALS measures by EMS and hospital personnel, the fire fighter died. NIOSH was notified of this fatality on May 18, 2004. On May 25, 2004, NIOSH contacted the FD to initiate an investigation. An investigator from the NIOSH Fire Fighter Fatality Investigation Team traveled to New York on July 29, 2004, to conduct an on-site investigation of this incident.

During this investigation, NIOSH personnel interviewed the following people:

- FD Chief
- FD Safety Officers
- Crew members
- EMS personnel
- Family members

During this investigation, NIOSH personnel reviewed the following documents:

- FD incident report
- Dispatch records for the incident
- Scene sketches
- Pre-hospital care report (ambulance run sheet)

## **INVESTIGATIVE RESULTS**

*Incident.* In the early evening hours of May 13, 2004, a working structure fire was reported. This 42-year-old volunteer FF was at home when the call was dispatched at 1722 hours. He responded directly to the scene in his privately owned vehicle. He is reported to have been one of the first FD members to arrive on scene, ahead of any FD apparatus by several minutes. Shortly thereafter, he was observed on the porch of the burning structure assisting the homeowners in removing their belongings. He performed this task without the protection of turnout gear or self-contained breathing apparatus (SCBA) as this equipment was stored on the rescue truck, which had not arrived on scene yet.

Fire apparatus began arriving on scene at 1730 hours. Weather information from the National Climatic Data Center revealed a dry bulb temperature of 25° Celsius (C) or [77° Fahrenheit (F)] and a wet bulb temperature of 22° C (71.6°F). Relative humidity was 79%. Upon arrival of the rescue truck, the FF retrieved his turnout gear and SCBA. After donning this protective equipment, he pulled approximately 150 feet of 2½” hose from the engine to the back of the structure. With this task completed, he pulled another 50 feet of 1½” hose from the engine to the front of the structure where he continued an exterior attack until relieved by another fire fighter. By all accounts, he used no air from his SCBA during this time.



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At approximately 1740 hours, he was seen sitting underneath a tree in front of the structure. Although he denied any symptoms, fellow crew members who observed him stated he “did not look right.” A crew member instructed the FF to remain underneath the tree while he summoned EMS personnel. The FF apparently walked across the street to the back of the rescue truck in search of water. When the crew member returned with EMS personnel, the FF was missing. After a 3-minute search of the area, the FF was found sitting at the rear of the rescue truck.

EMS reported that he appeared cyanotic and had a weak pulse and agonal respirations. He was lowered to the ground, and mouth-to-mouth ventilations were begun. Once the ambulance relocated from the other end of the fire scene, the FF was placed on the stretcher and loaded into the ambulance. Assisted ventilations with supplemental oxygen via a bag-valve mask were administered. The cardiac (heart) monitor was attached and showed ventricular fibrillation, a heart rhythm incompatible with life. He was immediately defibrillated according to ALS protocols when his heart stopped beating (asystole) after the second defibrillation. Chest compressions began at 1745 hours. The ambulance departed for the hospital’s emergency department (ED) at about 1753 hours. En route an intravenous (IV) line was established, and ALS medications were administered. The airway was secured with the placement of an endotracheal tube (ET tube) after two unsuccessful placement attempts. His heart rhythm remained asystolic despite the above interventions.

Upon hospital ED arrival at 1808 hours, the FF’s heart rhythm remained asystolic. ET tube placement was confirmed, and IV access was noted to

be flowing freely. ALS protocols were continued for an additional 7 minutes without a change in the FF’s condition. At 1815 hours, the attending physician pronounced the FF dead, and resuscitative efforts were stopped.

*Medical Findings.* The death certificate completed by the local medical examiner listed the immediate cause of death as an acute myocardial infarction (heart attack) contributed to by physical exertion in a hot, humid environment while fighting a structure fire. The coroner felt he had enough medical information to accurately complete the death certificate and that an autopsy was not necessary.

The FF was diagnosed with hypertension in 1999 by his primary care physician (PCP). Over the next 5 years, his blood pressure was under fair control due to intermittent compliance with prescription medications and dietary changes. From February to May 2004, the FD restricted the FF from interior fire suppression due to elevated blood pressure. During this 4-month period, the FF’s highest blood pressure measurement in the PCP’s office was 156/100 millimeters of mercury (mmHg).

The FF was also noted to have high blood cholesterol in 1999 by his PCP. His total cholesterol was 220 milligrams per deciliter (mg/dL) (normal < 200 mg/dL), and LDL cholesterol was 163 mg/dL (normal < 130 mg/dL). The medical records do not indicate that these results were ever discussed with the FF or that any lifestyle or dietary modifications were recommended. No cholesterol lowering medications were prescribed. His cholesterol was checked only one other time, in 2001, which showed a total cholesterol of 215 mg/dL and an LDL cholesterol of 136 mg/dL.



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In 2003, the FF was diagnosed with gastroesophageal reflux disease (GERD) for which he was started on a prescription medication. Family members reported that about 2 hours before his cardiac arrest he complained of nausea. Although it is unclear whether the nausea represented symptoms of GERD or possible angina, family members also noted that the FF was pale and was sweating earlier in the day.

### **DESCRIPTION OF THE FIRE DEPARTMENT**

At the time of this NIOSH investigation, the FD membership consisted of 1 Chief, 1 Assistant Chief, 35 volunteer fire fighters, and 6 Emergency Medical Technicians (EMTs) working out of a single, centralized station. They served a population of 1,843 spread over a 40-square-mile area. In 2003 the department responded to 200–225 calls, the majority of which were EMS calls; 25–50 were fire calls.

*Training.* Once accepted into the FD, new members must complete a prescribed set of courses tailored to job classification prior to active participation in FD activities. These requirements are detailed below:

- Interior Fire Fighter
  - Fire Fighter I Course
  - HAZMAT First Responder Course
  - Fire Fighter Survival
  - Emergency Vehicle Operations Course (EVOC)
  - Physical Class: A or B (in emergency situations)
- Exterior Fire Fighter
  - Fire Fighter Support
  - HAZMAT First Responder Course
- EVOC
- Physical Class: C or higher
- Pump Apparatus Operator
  - Fire Fighter I Course
  - HAZMAT First Responder Course
  - Pump Operators Course
  - EVOC
  - Physical Class: A, B, or C
- Fire Police
  - Must meet all requirements of an exterior fire fighter
  - Fire Police Certification
  - Physical Class: C or higher
- Rescue Squad Member
  - Valid CPR Card
  - Valid First Aid or EMT Certification
  - HAZMAT First Responder Operation Level
  - Bloodborne Pathogen (BBP) Training
  - EVOC

New members must meet these requirements within 3 years of acceptance into the FD.

*Pre-placement and Periodic Medical Evaluations.* New applicants are required to undergo a pre-placement medical evaluation prior to participating in fire suppression activities. In addition, the FD requires annual medical evaluations for interior fire fighters (Class A), but not others (Class B-C). Since 2003 these evaluations have been conducted by a local healthcare organization. At the time of this report, NIOSH investigators were unable to obtain information about the components of these pre-placement or periodic medical evaluations.



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Physical Fitness. At present, the department does not require periodic physical ability/agility testing. No fitness equipment is currently available at the fire station and no formal wellness program has been established.

## 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.<sup>1,2</sup> Risk factors for CAD development include age over 45, male gender, family history of CAD, smoking, hypertension (systolic blood pressure > 140 mmHg or diastolic blood pressure > 90 mmHg), hypercholesterolemia (total cholesterol > 240 mg/dL), obesity/physical inactivity, and diabetes.<sup>3,4</sup> The FF had three of these risk factors (male gender, hypertension, and physical inactivity). Although the FF's blood cholesterol was elevated, it did not reach the 240 mg/dL level used by the American Heart Association (AHA) to consider cholesterol a risk factor for CAD.

The local medical examiner listed "acute myocardial infarction" as the immediate cause of death on the death certificate. To definitively diagnose an acute myocardial infarction requires any of the following:

- a blood clot (thrombus) in the coronary artery found by catheterization or autopsy
- blood tests (cardiac isoenzymes)
- electrocardiogram (EKG) findings

The FF did not have an autopsy or an emergent catheterization to identify a thrombus; he died prior to the cardiac isoenzymes becoming posi-

tive, and he did not have any heartbeat on which to conduct an EKG. However, given the FF's clinical presentation, it is reasonable to conclude he suffered an acute myocardial infarction. While unlikely, another possible cause of his sudden death would be a massive pulmonary embolus. An autopsy could have ruled out this relatively rare condition.

Family members reported the FF complained of nausea 2 hours before this incident and that he had been pale and sweating earlier in the day. Nausea could have due to GERD; however nausea is sometimes an atypical presentation of angina. In either case, up to 20% of cases of CAD present as sudden cardiac death with no warning symptoms of angina.<sup>2</sup>

Narrowing of the coronary arteries by atherosclerotic plaques occurs over many years, typically decades.<sup>5</sup> However, the growth of these plaques probably occurs in a nonlinear, often abrupt fashion.<sup>6</sup> 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.<sup>7</sup> This sudden blockage is primarily due to blood clots (thrombosis) forming on the top of atherosclerotic plaques.

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.<sup>7</sup> Disruption then occurs from biomechanical and hemodynamic forces, such as increased blood pressure, increased heart rate, increased catecholamines, and shear forces that occur during heavy exercise.<sup>8,9</sup>



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Fire fighting is widely acknowledged as one of the most physically demanding and hazardous of all civilian occupations.<sup>10</sup> 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 to persist through the course of fire suppression activities.<sup>11-13</sup> 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.<sup>14</sup> Epidemiologic studies have found that heavy physical exertion sometimes immediately precedes and triggers the onset of acute heart attacks.<sup>15-18</sup>

The FF responded to a structure fire and performed fire suppression activities wearing full turnout gear in a hot and humid environment. The unseasonably hot weather and possible fluid loss (associated with reports of sweating earlier in the day) may have further added to the cardiovascular stress of the firefighting activity. It is known that physical work performed in the heat causes greater cardiovascular strain than similar work performed in thermal neutral environments<sup>19</sup> and that dehydration magnifies core temperature responses to work and exacerbates cardiovascular strain.<sup>20</sup> He pulled approximately 150 feet of 2½” hose from the engine to the back of the structure and then pulled another 50 feet of 1½” hose from the engine to the front of the structure where he continued an exterior attack for a total of 10-15 minutes. This is considered a very heavy level of physical exertion.<sup>21-22</sup> NIOSH investigators conclude that the FF’s heavy physical exertion, coupled with his probable underlying coronary artery disease (CAD), triggered his sudden cardiac death.

*Occupational Medical Standards for Structural Fire Fighters.* To reduce the risk of heart attacks and sudden cardiac arrest among fire fighters, the NFPA has developed the NFPA 1582 guidance document entitled *Comprehensive Occupational Medicine Program for Fire Departments.*<sup>23</sup> NFPA 1582 recommends annual medical evaluations for all fire fighters. This FD conducts annual medical evaluations only for fire fighters who are approved for interior fire suppression. NIOSH was unable to obtain the components of this FD’s annual evaluation, therefore, we cannot compare it to the NFPA document.

One controversial component of the NFPA 1582 Standard is the use of EST in asymptomatic fire fighters. NFPA 1582 recommends, for informational purposes only, screening asymptomatic fire fighters with two or more risk factors for CAD for obstructive CAD by an EST. NFPA defines these CAD risk factors as: family history of premature (first degree relative less than age 60) cardiac event, hypertension (diastolic blood pressure > 90 mmHg), diabetes mellitus, cigarette smoking, and hypercholesterolemia (total blood cholesterol level > 240 mg/dL).<sup>23</sup> This guidance is similar to, but not exactly the same as, recommendations from the American College of Cardiology/American Heart Association (ACC/AHA) and the Department of Transportation (DOT) regarding EST in asymptomatic individuals.<sup>24,25</sup> Because the FF had only one “NFPA” CAD risk factor (hypertension), an EST would NOT have been recommended by NFPA 1582, nor the AHA/ACC, nor the DOT guidelines. Thus, even if this FD was following the NFPA 1582 guidelines, it is unlikely it could have uncovered this FF’s CAD and prevented his sudden cardiac death at this time.



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## RECOMMENDATIONS

It is unlikely the following recommendations could have prevented the FF's death. Nonetheless, NIOSH investigators offer these recommendations to reduce the risk of on-the-job heart attacks and sudden cardiac arrest among fire fighters.

***Recommendation #1: Expand the current annual medical evaluation requirement to include Driver/Operators.***

The FD currently requires an annual medical evaluation for fire fighters participating in interior fire suppression. Given the potential risk to the public and other FFs if a Driver/Operator becomes suddenly incapacitated, the NIOSH investigator believes the FD should include Driver/Operators in this required evaluation.

The purpose of medical evaluations is to ensure that fire fighters have the ability to perform their duties without presenting a significant risk to the safety and health of themselves or others. Guidance for the content of these medical evaluations can be found in NFPA 1582.<sup>23</sup>

Conducting these comprehensive medical evaluations can be difficult for small, rural, volunteer FDs. To help ease the financial burden, the FD could encourage current members to obtain annual medical clearances from their private physicians (See Recommendation #3).

Another option would be to have the FD's EMTs conduct many portions of the evaluation (review medical histories, check vision, hearing, blood pressure, and EKGs). This information could then be provided to a community physician, perhaps volunteering his or her time, to review the data and provide medical clearance or request further

evaluation as indicated. Spreading out the financial responsibility for these evaluations between volunteers, the FD, and physician volunteers should reduce the financial impact on recruiting and retaining needed volunteers. These and other suggestions can be found in the National Volunteer Fire Council (NVFC) and United States Fire Administration's (USFA) *Health and Wellness Guide for the Volunteer Fire Service*.<sup>26</sup>

***Recommendation #2: Consider conducting EST for FFs with two or more cardiovascular risk factors.***

NFPA 1582 and the IAFF/IAFC wellness/fitness initiative recommend EST for fire fighters with two or more CAD risk factors.<sup>23,27</sup> The AHA states EST, may be indicated for individuals over 45 years of age with two or more risk factors for CAD.<sup>24</sup> 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.

***Recommendation #3: Ensure FFs are cleared for duty by a physician knowledgeable about the physical demands of fire fighting and the various components of NFPA 1582, and ensure that the results of these exams are discussed with the FFs.***

Physicians providing medical clearance for fire-fighting duties should be knowledgeable about the physical demands of fire fighting and familiar with the consensus guidelines published by NFPA 1582. To ensure that physicians performing medical clearance examinations are aware of these guidelines, it is recommended that the



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FD provide them with a copy of NFPA 1582. It is additionally recommended that the FD not automatically accept a primary care physician's opinion regarding a FF's ability to return to active duty. This decision requires knowledge not only of the FF's medical condition but also of the FF's job duties. Frequently, primary care physicians are not familiar with a FF's job description or with guidance documents such as NFPA 1582. Lastly, it is recommended that all return-to-work clearances be reviewed by a FD contracted physician. This places the final decision regarding medical clearance for return to active duty with the FD.

***Recommendation #4: Phase in a mandatory wellness/fitness program for FFs 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. This single risk factor predisposes individuals to the development of additional cardiovascular risk factors such as obesity and diabetes.<sup>28</sup> NFPA 1500, *Standard on Fire Department Occupational Safety and Health Program*, and NFPA 1583, *Standard on Health-Related Fitness Programs for Fire Fighters*, require a wellness program that provides health promotion activities for preventing health problems and enhancing overall well-being.<sup>29,30</sup> In 1997, the International Association of Fire Fighters (IAFF) and the International Association of Fire Chiefs (IAFC) published a comprehensive Fire Service Joint Labor Management Wellness/Fitness Initiative to improve fire fighter quality of life and to maintain physical and mental capabilities of fire fighters.

In January 2004, the National Volunteer Fire Council (NVFC) and USFA published a comprehensive Health and Wellness Guide for the Volunteer Fire Service to address the special circumstances sur-

rounding volunteer departments.<sup>26</sup> This FD, and other small volunteer FDs, should review the above programs and documents to determine which components are practical for them to implement.

***Recommendation #5: Conduct pre-placement and annual physical performance (physical ability) evaluations on FFs to ensure that they are physically capable of performing the essential job functions of structural fire fighting.***

NFPA 1500 requires FD members who engage in emergency operations to be annually evaluated and certified by the FD as meeting the physical performance requirements identified in paragraph 8-2.1.<sup>29</sup>

***Recommendation #6: Strengthen the FD's current rehabilitation program.***

An integral component of both an occupational safety and health program and incident scene management is an organized approach for fire department members' rehabilitation at incident scene operations. The concept of incident scene rehabilitation has been discussed and utilized throughout the fire service in various sizes and configurations. NFPA 1584 is a best practices guide for fire departments developing rehabilitation programs. We recommend the FD review this document to strengthen its current rehabilitation program.<sup>31</sup>

***Recommendation #7: Provide annual bloodborne pathogen (BBP) training to members likely to come into contact with blood while serving as a first responder.***

NFPA 1581 recommends that FDs provide annual bloodborne pathogen training for all members in accordance with State and Federal regulations.<sup>32</sup>



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**Recommendation #8: Perform an autopsy on all on-duty fire fighter fatalities.**

In 1995, the United States Fire Administration (USFA) published the Firefighter Autopsy Protocol,<sup>33</sup> which includes a recommendation for autopsies on all on-duty fire fighter fatalities. The USFA recommendation is designed to provide “a more thorough documentation of the causes of firefighter deaths for three purposes:

1. to secure eligibility for death benefits under the Federal government’s Public Safety Officer Benefits Program, [specifically the Hometown Heroes Survival Act].
2. 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;
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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