



Fire Fighter Suffers a Heart Attack and Dies Several Hours After Assisting at a Structure Fire – Illinois

SUMMARY

On July 29, 2006, a 43-year-old male paid/call Fire Fighter (FF) responded to a residential fire at 1917 hours. The fire occurred on a very hot (81 degrees Fahrenheit [°F]) and humid (77% relative humidity) evening. On-scene, the FF assisted in stretching the booster hose from the engine and setting up a positive pressure ventilation fan. During fire suppression operations, the FF and two other crew members had symptoms consistent with heat strain.

About 2 hours later, units returned to their fire station, and the FF returned home for the evening. Crew members called the FF at about 2130 hours to check on him, and he stated that he was feeling better. About an hour later, a crew member called the FF again, but this time the FF did not answer the telephone. The crew member asked his spouse to drive over to the FF's house and check to make sure he was alright. After ringing the doorbell and not getting any response, she entered the house and found the FF collapsed on the floor. She called 911 and began cardiopulmonary resuscitation (CPR). An ambulance arrived at his home 14 minutes later. Paramedics attached a cardiac monitor which revealed asystole (no heart beat). The coroner was notified and pronounced the FF dead via telephone. The death certificate (completed by the coroner) and autopsy (completed by the forensic pathologist) listed "fatal cardiac arrhythmia" due to "thrombosis of a severely narrowed artery" due to "clogged artery" as the cause of death. NIOSH investigators concluded that the heat and physical stress of

fire suppression probably triggered this FF's fatal heart attack.

NIOSH investigators offer the following recommendations to address general safety and health issues. However, it is unclear if any of these recommendations would have prevented the FF's sudden cardiac death.

- *Institute incident scene rehabilitation (rehab) during extensive structural fires.*
- *Perform pre-placement and periodic medical evaluations consistent with National Fire Protection Association (NFPA) 1582, Standard on Comprehensive Occupational Medical Program for Fire Departments.*
- *Develop a structured wellness/fitness program for fire fighters to reduce risk factors for cardiovascular disease and improve cardiovascular capacity.*

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

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- *Perform an annual physical performance (physical ability) evaluation to ensure fire fighters are physically capable of performing the essential job tasks of structural firefighting.*
- *Ensure fire fighters are cleared for duty by a physician knowledgeable about the physical demands of firefighting, the personal protective equipment used by fire fighters, and the various components of NFPA 1582.*
- *Provide fire fighters with medical evaluations and clearance to wear self-contained breathing apparatus (SCBAs).*
- *Ensure members report any medication use to the fire department physician.*

- Career Fire Chief
- FF's mother

NIOSH personnel reviewed the following documents:

- Fire Department incident reports
- Fire Department annual 2006 response report
- Fire Department standard operating guidelines
- Ambulance report
- Death certificate
- Autopsy report
- Primary care provider medical records

INTRODUCTION and METHODS

On July 29, 2006, a 43-year-old male paid/call FF died after responding to a structure fire. NIOSH was notified of this fatality on August 8, 2006 by the United States Fire Administration. NIOSH contacted the affected Fire Department on September 6, 2006 to obtain further information, and on May 11, 2007 to initiate the investigation. On May 21, 2007, a Safety and Occupational Health Specialist from the NIOSH Fire Fighter Fatality Investigation Team traveled to Illinois to conduct an on-site investigation of the incident.

During the investigation, NIOSH personnel interviewed the following people:

INVESTIGATIVE RESULTS

On July 29, 2006, the Fire Department was dispatched to a residential structure fire at 1917 hours. Equipment and personnel (1 engine, 1 tanker, 1 rescue/service truck, and 18 personnel) responded to the call, arriving on-scene at 1923 hours. Fire fighters found fire breaking through the roof directly above the kitchen area. Fire fighters, wearing full bunker gear and SCBA, entered the structure with a charged 1¾-inch hoseline and extinguished the fire. The weather conditions at this time included a temperature of about 81°F with 77% relative humidity, giving a heat index of 86°F.¹

The FF, walking on a bike trail about ½-mile from his vehicle, heard the dispatch and ran to his vehicle; then drove four blocks to the scene. He arrived at the scene at about 1933 hours, donned bunker gear, and assisted in stretching a booster hose from the engine. He then obtained a positive pressure ventilation fan and put it into operation. After about 10



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minutes, the FF became the third fire fighter to have symptoms of nausea, apparently due to the heat and humidity. The entire operation took about 1½-hours. The emergency was declared under control, and units departed the scene at 2100 hours.

During fire suppression operations, the Chief (the Incident Commander for this fire) recommended the three fire fighters seek medical treatment at the local hospital, but all three refused. No rehab sector was established at the fire scene but hydrating fluids were available. Their symptoms persisted through the remainder of the incident (about 75 minutes). Prior to leaving the scene, the Fire Chief checked on the FF, who stated he was going home. A crew member called the FF to check on him at 2130 hours, and the FF reported he vomited once, but had taken a shower and was feeling better, despite some persistent indigestion. About an hour later, crew members again tried to check up on the FF via telephone. This time they were unable to reach him. A crew member's spouse drove to the FF's house to check on him (2227 hours). She rang the doorbell but received no response. She peered into the window and saw him lying on the floor. She entered the house and found the FF unresponsive, without a pulse, and not breathing. She called 911 (2230 hours) and began CPR.

The ambulance was dispatched at 2231 hours and responded at 2234 hours, arriving at the scene at 2244 hours (it had been on standby at an event in another town). Ambulance paramedics found the FF unresponsive, not breathing and without a pulse, cool and cyanotic, with CPR in progress. A cardiac monitor attached to the FF revealed asystole

(no heart beat) in two leads. Police officers arrived and notified the coroner, who pronounced the FF dead at 2244 hours via telephone. There was discrepancy of a few minutes between the ambulance and death certificate timeline.

Medical Findings. The death certificate (completed by the coroner) and autopsy (completed by the forensic pathologist) listed “fatal cardiac arrhythmia” due to “thrombosis of a severely narrowed artery” due to “clogged artery” as the cause of death. Pertinent findings from the autopsy, performed on July 30, 2006, included the following:

- Atherosclerotic cardiovascular disease
 - Severe (80%) narrowing of the left anterior descending coronary artery
 - Thrombus in the left anterior descending coronary artery
 - Moderate (50%) narrowing of the right coronary artery
- Cardiomegaly (heart weighed 580 grams [g]) (normal weight is <400 g)²
 - Left ventricular hypertrophy (left ventricle 16-20 millimeters [mm] thick) (normal thickness is 7.6-8.8 mm)³
- No evidence of a pulmonary embolus (blood clot in the lung arteries)
- Negative alcohol tests
- Drug testing was positive for prescription medication hydrocodone (13 nanograms [ng] per milliliter [mL]) (therapeutic level is 10 - 40 ng/mL)
- Carbon monoxide blood level of 5.6% (normal for a smoker)

The FF was 75” tall and weighed 304 pounds, giving him a body mass index (BMI) of 37.99.



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A BMI >30.0 kilograms per meters squared (kg/m²) is considered obese.⁴ The FF had a history of hypertension and was prescribed two antihypertensive medications. His triglycerides were elevated while his high-density lipoprotein (HDL) was low on two occasions (2003 and 2006), but he was not diagnosed with hyperlipidemia, nor was he prescribed a low fat diet or a lipid-lowering medication. Also, he smoked cigars. There was no family history of coronary artery disease. The FF had a tooth pulled 3 days prior to his death and had been prescribed hydrocodone as a painkiller.

DESCRIPTION OF THE FIRE DEPARTMENT

At the time of the NIOSH investigation, this Fire Department consisted of 27 uniformed personnel (1 career Fire Chief and 26 paid/call members), served a population of 7,500 in a 100-square-mile area, and had 1 fire station. In 2006, the Fire Department responded to 107 calls including: 21 structure fires, 11 tree/grass/brush fires, 6 vehicle fires, 1 rubbish fire, 7 rescue calls, 7 hazardous condition calls, 21 false alarm calls, 17 good intent calls, and 16 service calls.

Membership and Training. The Fire Department requires the following of all fire fighter applicants:

- complete an application
- possess a valid State driver's license
- be over 18 years of age
- pass an oral interview

The applicant is voted on by the general membership. The successful applicant is

accepted into the Fire Department and is encouraged to enroll in fire science classes at the local college. Additional training is conducted at the Fire Department to train the applicant to the Fire Fighter 2 (FF2) level (230 hours). The new fire fighter must attend drills and respond to 25% of the calls. The State minimum standard for fire fighter certification is FF2.

The FF was certified as an FF2, Emergency Medical Technician (EMT), Instructor 1, and in Hazardous Materials awareness. He had 10 years of firefighting experience.

Pre-placement and Periodic Medical Evaluations. No pre-placement or periodic medical evaluations are required by this Fire Department. Medical clearance for SCBA use is not required. If someone is injured at work, a return-to-duty medical clearance is required from the fire fighter's primary care physician and provided to the City's Worker's Compensation clerk, who makes the final clearance decision.

Health/Wellness. An annual physical agility test is not required for members. No wellness/fitness program or aerobic and strength equipment are available.

DISCUSSION

Coronary Artery Disease (CAD) and the Pathophysiology of Sudden Cardiac Death. In the United States, CAD (atherosclerosis) is the most common risk factor for cardiac arrest and sudden cardiac death.⁵ Risk factors for its development include increasing age, male gender, heredity, tobacco smoking, diabetes,



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high blood cholesterol, high blood pressure, and physical inactivity/obesity.⁶ The FF had four American Heart Association (AHA) risk factors for CAD: male gender, high blood pressure, tobacco smoking, and obesity. He had CAD based on his autopsy report, but the FF did not report symptoms of angina (e.g., chest pain on exertion) prior to his collapse or in the months/years prior to his death. However, he did report nausea and vomiting prior to his collapse. It is unclear if the symptoms were due to heat stress or his “angina equivalent” (cardiac symptom other than chest pain).

Patients with severe CAD are at risk for heart attacks. Heart attacks occur with the sudden development of complete blockage (occlusion) in one or more coronary arteries that have not developed a collateral blood supply.⁷ This sudden blockage is primarily due to blood clots (thromboses) forming on top of atherosclerotic plaques. At autopsy, the FF had a thrombus in his left anterior descending coronary artery, thus confirming his heart attack.

Blood clots in coronary arteries are initiated by disruption of atherosclerotic plaques. Certain characteristics of the plaques (size, composition of the cap and core, and presence of a local inflammatory process) predispose the plaque to disruption.⁷ Disruption then occurs from biomechanical and hemodynamic forces, such as increased blood pressure, increased heart rate, increased catecholamines, and shear forces, which occur during heavy exercise.⁸

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. 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.¹⁰ The FF ran ½-mile to his vehicle and responded to the structure fire. On-scene, the FF (while wearing full bunker gear) assisted in pulling the booster hose and setting up a positive pressure ventilation fan in high ambient temperature and humidity. This is considered a heavy level of physical exertion.^{9,11}

Epidemiologic studies have found that heavy physical exertion sometimes immediately precedes and triggers the onset of acute heart attacks.¹²⁻¹⁵ The physical stress of running ½-mile, pulling the booster hose and setting up a positive pressure ventilation fan (while wearing full bunker gear in high ambient temperature and humidity), and the FF’s underlying CAD, could have triggered the thrombus, causing a heart attack which caused a heart arrhythmia and sudden cardiac death.^{16,17}

Left Ventricular Hypertrophy. On autopsy, the FF was found to have left ventricular hypertrophy and an enlarged heart. Hypertrophy of the heart’s left ventricle is a relatively common finding among individuals with long-standing high blood pressure (hypertension), a heart valve problem, or chronic cardiac ischemia (reduced blood supply to the heart muscle).¹ The FF’s left ventricular hypertrophy was likely due to his



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high blood pressure. Both conditions, the left ventricular hypertrophy and hypertension, increase the risk for sudden cardiac death.¹

Heat Stress/Strain. Heat stress is the exposure to heat loads. Sources of heat include the metabolic cost of work, environmental factors, (i.e., air temperature, humidity, air movement, and radiant heat exchange), and clothing requirements.¹⁸ Heat strain is the overall physiological response resulting from heat stress.¹⁸ Sudden and severe fatigue, nausea, dizziness, or lightheadedness are symptoms of heat strain and should trigger removal from heat sources. Some common heat-related disorders include heat syncope, dehydration and loss of electrolytes, heat exhaustion, and heat stroke. Heat-related disorders vary in degree of severity, although all but heat stroke resolve with no lasting complications.¹⁸

The prime objective of heat stress management is the prevention of heat stroke, which is life-threatening and the most serious of the heat-related disorders.¹⁸ The likelihood and severity of heat strain experienced by an individual for a given level of heat stress depends on the physiological capacity of that individual to respond to the stress.¹⁸ Personal risk factors such as age, obesity, state of hydration, use of medications and drugs, gender, and acclimatization state may reduce an individual's tolerance for heat stress.¹⁸ The environmental conditions and the fact that other fire fighters had nausea suggest that the FF's symptoms probably were due to heat exhaustion. However, we cannot rule out that his nausea and vomiting were symptoms of a heart attack.¹⁹ Due to the environmental conditions and work activities, the Incident Commander should have set up a rehab unit to

triage the symptomatic FFs and provide climatic relief from heat stress.

Occupational Medical Standards for Structural Fire Fighters. To reduce the risk of sudden cardiac death or other incapacitating medical conditions among fire fighters, the NFPA developed NFPA 1582.²⁰ NFPA 1582 recommends an electrocardiogram (EKG) as part of the annual medical evaluation. An EKG within the past year probably would have detected the FF's left ventricular hypertrophy. If left ventricular hypertrophy had been detected, perhaps the FF would have been referred for further medical evaluation (e.g., an echocardiogram).

NFPA 1582 considers use of narcotic painkillers to compromise the member's ability to safely perform 12 essential job tasks for structural fire fighting.²⁰ The FF should have reported this medication use to the Fire Department so a determination could be made regarding work restrictions. Because the Fire Department did not have a physician, the Fire Chief or the City Worker's Compensation clerk should have been notified.

RECOMMENDATIONS

NIOSH investigators offer the following recommendations to address general safety and health issues. However, it is unclear if any of these recommendations would have prevented the FF's sudden cardiac death.

Recommendation #1: Institute incident scene rehabilitation (rehab) during extensive structural fires.



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The Incident Commander should consider the circumstances of each incident in determining the need for rehabilitation.²¹ Members performing intense work for 20 minutes without SCBA should receive at least 10 minutes of self-rehab.²² Rehab should be located sufficiently far away from the effects of the operation so that members can safely remove their personal protective equipment and SCBA.²² On-scene rehab should be staffed, include at least basic life support, and have fluid and food available.²² Members entering rehab should receive medical monitoring including rating of perceived exertion, heart rate, blood pressure, and temperature.²² While the fire at this incident was considered a routine residential fire, fire fighters performed heavy physical exertion while effecting fire suppression activities during elevated temperature and humidity. Therefore, NIOSH investigators believe rehab should have been established, and the symptomatic FFs should have been assigned to rehab for evaluation and treatment. In addition, under the incident command system, the Incident Commander could have required the symptomatic FFs to go to the hospital's emergency department for evaluation.

Recommendation #2: Perform pre-placement and periodic medical evaluations consistent with National Fire Protection Association (NFPA) 1582, Standard on Comprehensive Occupational Medical Program for Fire Departments.

NFPA 1582 requires fire departments to conduct pre-placement and annual medical evaluations. Guidance regarding the content and frequency of these evaluations can be

found in NFPA 1582²⁰ and in the International Association of Fire Fighters (IAFF) / International Association of Fire Chiefs (IAFC) *Fire Service Joint Labor Management Wellness/Fitness Initiative*.²³ However, the Fire Department is not legally required to follow this standard or this initiative. Applying this recommendation involves economic repercussions and may be particularly difficult for small, volunteer or combination fire departments to implement. NFPA 1500, *Standard on Fire Department Occupational Safety and Health Program*, Chapters 8-7.1 and 8-7.2²¹ and the National Volunteer Fire Council (NVFC) *Health and Wellness Guide*²⁴ address these issues.

To overcome the financial obstacle, the Fire Department could urge current members to get annual medical clearances from their private physicians. Another option is having the annual medical evaluations completed by paramedics and EMTs from the Emergency Medical Service (vital signs, height, weight, visual acuity, and EKG). 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 further evaluation, if needed). The more extensive portions of the medical evaluations could be performed by a private physician at the fire fighter's expense (personal or through insurance), provided by a physician volunteer, or paid for by the Fire Department. Sharing the financial responsibility for these evaluations between fire fighters, the Fire Department, and physician volunteers may reduce the negative financial impact on recruiting and retaining needed fire fighters.



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Recommendation #3: Develop a structured 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. Physical inactivity, or lack of exercise, is associated with other risk factors, including obesity and diabetes.²⁵ NFPA 1500 requires that a Fire Department have a wellness program that provides health promotion activities for preventing health problems and enhancing overall well-being.²¹ Wellness programs have been shown to be cost effective, typically by reducing the number of work-related injuries and lost work days.²⁶⁻²⁸ Health promotion programs in the fire service have been shown to reduce CAD risk factors and improve fitness levels, with mandatory programs showing the most benefit.²⁹⁻³¹ One mandatory program was able to show a cost savings of \$68,741 due to reduced absenteeism.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 Guidance for implementation and components of a wellness/fitness program are found in NFPA 1583, *Standard on Health-Related Fitness Programs for Fire Fighters*,³⁴ in the IAFF/IAFC's *Fire Service Joint Labor Management Wellness/Fitness Initiative*,²³ and in the NVFC's *Health and Wellness Guide*.²⁴ Given the structure of the FF's Fire Department, the NVFC program might be the most appropriate model. NIOSH recommends a formal, structured wellness/fitness program to ensure all members receive the benefits of physical exercise. Even though the Fire

Department does not have exercise equipment in the fire station, fire fighters could use other local facilities such as the school, fitness club, or equipment at home.

Recommendation #4: Perform an annual physical performance (physical ability) evaluation to ensure fire fighters are physically capable of performing the essential job tasks of structural firefighting.

NFPA 1500 requires Fire Department members who engage in emergency operations to be annually evaluated and certified by the Fire Department as having met the physical performance requirements identified in paragraph 8-2.1 of the standard.²¹

Recommendation #5: Ensure fire fighters are cleared for duty by a physician knowledgeable about the physical demands of firefighting, the personal protective equipment used by fire fighters, and the various components of NFPA 1582.

Guidance regarding medical evaluations and examinations for structural fire fighters can be found in NFPA 1582²⁰ and in the report of the IAFF/IAFC *Fire Service Joint Labor Management Wellness/Fitness Initiative*.²³ According to these guidelines, the Fire Department should have an officially designated physician who is responsible for guiding, directing, and advising the members with regard to their health, fitness, and suitability for duty as required by NFPA 1500.²¹ The physician should review job descriptions and essential job tasks required for all Fire Department positions and ranks, in order to understand the physiological and psychological demands of fire fighters and the



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environmental conditions under which they must perform, as well as the personal protective equipment they must wear during various types of emergency operations.

Recommendation #6: Provide fire fighters with medical evaluations and clearance to wear self-contained breathing apparatus (SCBAs).

The Occupational Safety and Health Administration (OSHA)'s *Revised Respiratory Protection Standard* requires employers to provide medical evaluations and clearance for employees using respiratory protection.³⁵ Such employees include fire fighters who utilize SCBA in the performance of their duties. These clearance evaluations are required for private industry employees and public employees in States operating OSHA-approved State plans. Illinois is a State-plan State, and public sector employers are required to comply with OSHA standards.

Recommendation #7: Ensure members report any medication use to the Fire department physician.

NFPA 1582 requires fire department members to “report to the fire department physician any medical condition that could interfere with the ability of the individual to safely perform essential job tasks, such as illness or injury, use of prescription or nonprescription drugs, and pregnancy.”²⁰ If the Fire Department had a contract Fire Department physician, perhaps the FF would have provided this information.

However, it is unlikely the use of hydrocodone was a factor in the FF's sudden cardiac death.

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