



Wildland Fire Fighter Suffers Sudden Cardiac Death After Performing Mop-Up/Overhaul Operations at Two Wildland Fires – Florida

SUMMARY

On February 21, 2005, a 37-year-old male career Wildland Fire Fighter (WFF) conducted mop-up/overhaul operations at two wildland fire sites. Later that day he returned to the district office where he vigorously exercised at the end of his shift and departed for home complaining of indigestion. Later that evening, while talking to a neighbor, the WFF collapsed at approximately 1817 hours.

When the neighbor drove his car to notify emergency medical service (EMS), he encountered the WFF's wife less than a minute from the home. She returned home to find her husband unresponsive, and she called 911. Non-EMS trained bystanders attempted chest compression until EMS arrived at 1831 hours and found the WFF unresponsive with no breath sounds, pulse, or blood pressure. He was ventilated using a bag valve mask, placed on a heart monitor, and found to be in ventricular fibrillation (a rhythm incompatible with life). A defibrillation (shock) was immediately delivered, but his heart rhythm converted to asystole (no heart beat). Despite ALS provided by ambulance paramedics on scene and en route to the hospital, and by the hospital emergency department (ED) staff, the WFF died.

The death certificate and autopsy, completed and performed by the Chief Medical Examiner listed "left anterior descending coronary artery thrombosis" as the immediate cause of death. The physical stress of conducting mop-up/overhaul operations and his vigorous physical fitness training, coupled with his underlying atherosclerotic coronary artery disease (CAD) contributed to this WFF's sudden cardiac death.

It is unlikely that programs such as those recommended here could have prevented the WFF'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.

- *Provide mandatory pre-placement and annual medical evaluations to ALL fire fighters consistent with the most recent edition (2003) of NFPA 1582, Standard on Comprehensive Occupational Medical Program for Fire Departments.*
- *Phase in a mandatory wellness/fitness program for fire fighters to reduce risk factors for cardiovascular disease and improve cardiovascular capacity.*
- *Perform an annual physical performance (physical ability) evaluation to ensure all fire fighters are physically capable of performing the essential job tasks of wildland fire fighting.*

INTRODUCTION & METHODS

On February 21, 2005, a 37-year-old male WFF collapsed at his home and died shortly thereafter. NIOSH was notified by the US Fire Academy on March 1, 2005. On March 18, 2005, NIOSH contacted the affected state forestry district office to initiate the investigation. On August 29, 2005, an Occupational Health Nurse Practitioner from the NIOSH Fire

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



Wildland Fire Fighter Suffers Sudden Cardiac Death After Performing Mop-Up/Overhaul Operations at Two Wildland Fires – Florida

Fighter Fatality Investigation Team traveled to Florida to conduct an on-site investigation of the incident.

During the investigation NIOSH personnel interviewed the following people:

- Division Safety Officer
- District Manager
- Forest Area Supervisor
- Crew member
- Wildland fire fighter's wife

During the site visit NIOSH personnel reviewed the following documents:

- Division policies and operating guidelines
- FD training records
- FD annual report for 2004
- Ambulance response report
- Hospital records
- Past medical records
- Autopsy results
- Death certificate

INVESTIGATIVE RESULTS

Incident. On February 21, 2005, the WFF reported for work at approximately 0800 hours. He and another crew member went to the sites of two previous fires (9 and 20 acres in size) to check for re-ignition and perform mop-up/overhaul operations using hand tools and hoses as needed. They completed these tasks at approximately 1200 hours and returned to the station. After lunch they completed paperwork until approximately 1600 hours. At this point the WFF and two other crew members moved to an adjacent building for physical fitness training. The WFF lifted weights, bench pressing 315 pounds five or six times. He jumped rope for aerobic exercise. The WFF complained of indigestion throughout the exercise period but continued working out until he departed for home at approximately 1700 hours.

Once home, the WFF took four Alka-Seltzer Plus™ and two Pepcid-ACs™. The empty packages were

found by his wife on the kitchen counter. He went outdoors and began talking to his neighbor, who witnessed his collapse at approximately 1817 hours. The neighbor decided to drive his car to get help and less than 50 yards from the home encountered the WFF's wife. The neighbor explained the situation to her and she immediately drove home. She found her husband unresponsive and called 911 at 1826 hours. Non-EMS trained bystanders attempted to provide chest compressions until the ambulance arrived at 1831 hours (14 minutes after his collapse). When the paramedics arrived they found the WFF unresponsive with no breath sounds, pulse, or blood pressure. Simultaneously, the WFF was placed on a monitor and found to be in ventricular fibrillation, while an oropharyngeal airway was placed into the WFF's mouth and a bag valve mask was used to administer oxygen. Defibrillation was immediately attempted, but his heart rhythm converted to asystole (no heart beat). The paramedics transferred him to the ambulance via a stretcher. An intravenous line was placed, and an attempt to intubate (insert a breathing tube into the WFF's windpipe) was made. When this intubation was unsuccessful a Combi-tube™ was inserted and, after checking bilateral breath sounds, ventilation was begun. The WFF remained unresponsive with no heartbeat when the ambulance departed for the hospital at 1847 hours.

En route to the hospital ALS medications were administered with no change in status. The ambulance arrived at the ED at 1909 hours. The ED staff found the WFF in asystole with no pulse and receiving oxygen through a Combi-tube™ and bag valve mask. Intubation was performed and verified by listening to bilateral breath sounds. Further ALS medications were administered for 11 minutes until resuscitation attempts were halted and the WFF was declared dead at approximately 1920 hours (a little over an hour after his collapse).

Medical Findings. The death certificate and autopsy, completed by the Chief Medical Examiner, listed "left anterior descending coronary artery thrombosis"



Wildland Fire Fighter Suffers Sudden Cardiac Death After Performing Mop-Up/Overhaul Operations at Two Wildland Fires – Florida

as the cause of death. Significant findings from the autopsy were as follows:

- Attached thrombus (blood clot) with complete occlusion and focally a pinpoint lumen for about 1.5 cm in the proximal left anterior descending coronary artery
- Chronic myocardial ischemia
 - Fibrosis in the mid septum, just below the right aortic cusp, and near the apex of the heart (strongly suggestive of a remote heart attack)
 - Heart weight 450 grams (normal < 400 grams)
 - Left ventricular walls measure 1.4 centimeters (cm) in thickness (normal is 0.6-1.1 cm)

The WFF had no history of coronary artery disease (CAD). He was never diagnosed with CAD risk factors, although serial blood pressures taken by his primary care provider were borderline elevated (140/90 millimeters of mercury [mm/Hg] to 150/100 mm/Hg). His last blood pressure measurement, in March 2004, was 132/90 mm/Hg. His most recent blood tests (1990) for cholesterol and triglycerides were normal. At the time of death he was 5'9" and weighed 210 pounds, giving him a body mass index of 31 kilograms/meters² (kg/m²). A BMI over 30 kg/m² is considered obese.¹ Prior to departing for home, he told crew members he had indigestion, but he voiced no other signs or symptoms of chest pain or discomfort to his wife, co-workers, or health care providers prior to this incident. He had no family history of heart disease. His spouse mentioned that he spoke of having a heart murmur as a child, but no medical records available to NIOSH support that statement.

DESCRIPTION OF THE FIRE DISTRICT

At the time of the NIOSH investigation, the FD consisted of 28 career wildland fire fighters. Its 10 fire stations conduct fire protection for state forests

and wildlands. Mutual aid procedures are followed using the urban/wildland interface, but structural fire fighting is performed by the county fire and rescue services. In 2004, the FD responded to 157 wildland fires.

Pre-placement Medical Evaluations and Training.

The FD requires all new wildland fire fighter applicants to complete an application and pass a urine drug test. Successful applicants are given a medical evaluation using the National Fire Protection Association (NFPA) 1582 *Medical Requirement for Firefighters*, 1992 edition (see below). After successfully passing the medical evaluation, the new employee must complete a pack test, a physical fitness test that requires the applicant to hike 2 miles on level terrain in 30 minutes or less while carrying a 25-pound backpack.

The new hire must complete various wildland fire fighter classes taught at the State level that equate to the NFPA Wildland Fire Fighter I and II criteria. New hires also must attend a 2-week structural fire fighter course as part of this basic fire control training program. The WFF was a certified Wildland Fire Fighter I and II, Hazmat, Driver/Operator and Fire Investigator, and had 17 years of WFF experience.

The FD requires a pre-placement medical evaluation based on the NFPA 1582, 1992 edition. Components of the evaluation include the following:

- Complete medical history
- Physical examination
- Vital signs including height and weight
- Vision testing (acuity, color, and peripheral)
- Audiogram
- Blood analysis: (serum chemistry, lipid panel, and liver profile, complete blood count)
- Urinalysis (dipstick)
- Drug screen (urine)
- Pulmonary function test (spirometry)
- Chest x-ray
- 12-lead resting electrocardiogram (EKG)



Wildland Fire Fighter Suffers Sudden Cardiac Death After Performing Mop-Up/Overhaul Operations at Two Wildland Fires – Florida

Periodic Medical Evaluations. Wildland Fire Fighters hired after 1991 are required to undergo an annual medical exam, which consists of vital signs and pulmonary function testing. Wildland Fire Fighters hired before 1991 are not required to undergo medical exams unless they want a certification card to work outside the state. In order to gain the WFF certification card (“red card”), fire fighters have to undergo the health assessment and work capacity tests of the National Wildfire Coordinating Group (NWCG) that are necessary for the assignment. A state contracted physician must evaluate employees injured at work and clear them for return to work. Employees returning from an illness that required more than 3 days off work may be required to provide a return to work form completed by their primary care provider.

Fitness/Wellness Programs. The pack test described above is a mandatory annual physical ability test for every WFF hired after 1991. The unstructured fitness program is voluntary and no equipment is available while on duty. Wellness/health maintenance programs (smoking cessation, weight control, high blood pressure, diabetes, and cholesterol) are offered by this department through its Employee Assistance Program.

DISCUSSION

In the United States, atherosclerotic CAD is the most common risk factor for cardiac arrest and sudden cardiac death.² Risk factors for its development include age over 45, male gender, family history of coronary artery disease, smoking, high blood pressure (systolic > 140 mmHg or diastolic > 90 mmHg), high blood cholesterol (total cholesterol > 240 milligrams per deciliter [mg/dL]), obesity/physical inactivity, and diabetes.^{3,4} The WFF had one, possibly two, of these risk factors (male gender and high blood pressure).

The narrowing of the coronary arteries by atherosclerotic plaques occurs over many years, typically decades.⁵ However, the growth of these plaques probably occurs in a nonlinear, often abrupt fashion.⁶ 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.⁷ This sudden blockage is primarily due to blood clots (thrombosis) forming on top of atherosclerotic plaques. The WFF had a blood clot in his left anterior descending coronary artery. This finding confirms that a heart attack (medically known as a myocardial infarction [MI]) and an associated heart arrhythmia were responsible for his sudden cardiac death. Most life threatening arrhythmias associated with MIs occur during the 24 hours after symptoms first began.⁸⁻¹¹ The WFF also had evidence of a remote heart attack on autopsy (fibrosis). Since no other coronary arteries displayed atherosclerosis, it appears that the WFF suffered two prior MI’s caused by the lesion found in the proximal left anterior descending coronary artery (6% of all patients with MIs do not have atherosclerosis).¹² After these two MI’s, recanalization occurred (forming a pinpoint lumen) until the thrombus occluded the proximal left anterior descending coronary artery leading to his death.

Angina (chest pain) is the most common presenting symptom of myocardial ischemia and underlying CAD. But, in many persons the first evidence of CAD may be MI or sudden death.¹³ With up to 20% of heart attacks being “silent,” (i.e., painless), some individuals may not experience angina with ischemia.⁵ Other individuals experience “atypical” angina (e.g. indigestion, back pain, nausea/vomiting, or fatigue). In this case, indigestion was probably reflecting angina.

Fire fighting is widely acknowledged to be one of the most physically demanding and hazardous of all civilian occupations.¹⁴ 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 fire scene and to persist through the course of fire suppression activities.¹⁵⁻¹⁷ 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 WFF personal protective clothing.¹⁸



Wildland Fire Fighter Suffers Sudden Cardiac Death After Performing Mop-Up/Overhaul Operations at Two Wildland Fires – Florida

Epidemiologic studies have found that heavy physical exertion sometimes immediately precedes and triggers the onset of acute heart attacks.¹⁹⁻²² The WFF had performed at heavy exertional levels while conducting mop-up/overhaul, then returned to exercise in the station at the end of his shift.^{23,24} The physical stress of mop-up and exercising in an individual with underlying atherosclerotic CAD contributed to sudden cardiac death.

Atherosclerosis in a coronary artery may cause ischemic heart disease. This occurs when the blood flow within a coronary artery, the left descending coronary artery in this case, is limited to the point where the oxygen needs of the heart muscle cannot be met. Chronic ischemic heart disease causes hypertrophy of the heart muscle and cardiomegaly. All of these factors, independently and in combination (ischemia, left ventricular hypertrophy, cardiomegaly, or myocardial infarction), increase the risk of cardiac arrhythmia.

Occupational Medical Standards for Structural Fire Fighting and the Use of the Exercise Stress Test to Screen for CAD. To reduce the risk of sudden cardiac arrest or other incapacitating medical conditions among fire fighters, the NFPA has developed guidelines entitled *Standard on Comprehensive Occupational Medical Program for Fire Departments*, otherwise known as NFPA 1582.²⁵ To screen for CAD, NFPA 1582 recommends an exercise stress test (EST) for asymptomatic fire fighters with two or more risk factors for CAD (family history of premature [less than age 60] cardiac event, hypertension [diastolic blood pressure greater than 90 mmHg], diabetes mellitus, cigarette smoking, and hypercholesterolemia [total cholesterol greater than 240 mg/dl]).²⁵ This recommendation is consistent with recommendations from the American Heart Association/American College of Cardiology (AHA/ACC) and the Department of Transportation (DOT) regarding EST in asymptomatic individuals.^{26,27} Because the WFF was under 45 years of age, asymptomatic, and possibly had one risk factor for CAD, the performance of an EST would have been indicated by neither the NFPA 1582 nor AHA/ACC.

On the other hand, the U.S. Preventive Services Task Force (USPSTF) indicates that there is insufficient evidence 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.”²⁸ If an EST had been performed, the WFF’s CAD might have been detected, resulting in further evaluation and treatment, and possibly preventing his sudden cardiac death.

The WFF had left ventricular hypertrophy on autopsy. 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 cardiac ischemia (reduced blood supply to the heart muscle). However, the WFF was never diagnosed with high blood pressure although he had numerous elevated readings, and, on autopsy, did not have any valve abnormalities. He did have CAD, therefore cardiac ischemia is a distinct possibility, particularly given his atherosclerotic disease and the findings of fibrosis in his left ventricle strongly suggestive of an old MI.

RECOMMENDATIONS

It is unlikely the following recommendations could have prevented the WFF’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.

Recommendation #1: Provide mandatory pre-placement and annual medical evaluations to ALL fire fighters consistent with NFPA 1582, Standard on Comprehensive Occupational Medical Program for Fire Departments²⁵ to determine their medical ability to perform duties without presenting a significant risk to the safety and health of themselves or others.



Wildland Fire Fighter Suffers Sudden Cardiac Death After Performing Mop-Up/Overhaul Operations at Two Wildland Fires – Florida

We applaud the efforts of the Division for implementing a comprehensive medical evaluation and examination program. This program, however, appears to be based on the 1992 edition of NFPA 1582. In the fall of 2003, NFPA issued a significantly revised edition. A copy of the revised edition has been provided to the district office.

Guidance regarding the content and frequency of pre-placement and periodic medical evaluations and examinations for fire fighters can be found in NFPA 1582 and in the report of the International Association of Fire Fighters/International Association of Fire Chiefs (IAFF/IAFC) *Wellness/Fitness Initiative*.²⁹ The district is not legally required to follow any of these standards.

Recommendation #2: Phase in a mandatory wellness/fitness program for fire fighters to reduce risk factors for cardiovascular disease and improve cardiovascular capacity.

NFPA 1500 requires a wellness program that provides health promotion activities for preventing health problems and enhancing overall well-being.³⁰ The IAFF and the IAFC 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.²⁹ Wellness programs have been shown to be cost effective, typically by reducing the number of work-related injuries and lost work days.^{31,32} 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 disability pension costs.³³ The FD should implement this recommendation to ensure CAD risk factors are reduced and cardiovascular capacity is increased.

Recommendation #3: Perform an annual physical performance (physical ability) evaluation

to ensure fire fighters are physically capable of performing the essential job tasks of wildland fire fighting.

Although the physical ability test is mandatory for WFFs hired after 1991, NFPA 1500, *Standard on Fire Department Occupational Safety and Health Programs* requires all members who engage in emergency operations to be annually evaluated and certified as meeting the physical performance requirements identified in paragraph 10.2.4.³⁰ The WFF possessed a state-issued certification card recognized by the NWCG as sufficient for a moderate duty wildland fire fighter. It was not recognized as sufficient for arduous duty. Even though the department does a needs-based work capacity test for out of state work, the physical performance requirements for in-state and out of state would be similar; therefore we suggest the state forestry department follow the guidelines of the NWCG's *Work Capacity Test: Administrator's Guide*.³⁴

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Wildland Fire Fighter Suffers Sudden Cardiac Death After Performing Mop-Up/Overhaul Operations at Two Wildland Fires – Florida

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Wildland Fire Fighter Suffers Sudden Cardiac Death After Performing Mop-Up/Overhaul Operations at Two Wildland Fires – Florida

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