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NIOSH
Fire Fighter Fatality Investigation and Prevention Program

Death in the line of duty...

A summary of a NIOSH fire fighter fatality investigation *May 2008*

Volunteer Fire Fighter Dies While Performing Exterior Fire Suppression at a Large Machine Shed Fire - Illinois

SUMMARY

On May 6, 2007, a 54-year-old male volunteer Fire Fighter (FF) responded to a fire in a large machine shed. While operating an external attack hose line for about 20 minutes, the FF collapsed. Cardiopulmonary resuscitation (CPR) was begun immediately by on scene emergency medical service (EMS) personnel. An automated external defibrillator (AED) was retrieved from the on scene ambulance and attached to the FF within two minutes of his collapse. Two defibrillations were delivered without a change in the FF's condition. Advanced life support was administered en route to the hospital, and in the hospital's emergency department. Despite these efforts, the FF could not be revived. The death certificate and the autopsy listed "Coronary Atherosclerosis" as the immediate cause of death. The NIOSH investigator considered that responding to the fire alarm and the physical effort needed to sustain the exterior fire suppression could have triggered a probable heart attack and the subsequent sudden cardiac death of this FF.

It is unclear if any of the following recommendations could have prevented the death of this FF at this time. Nonetheless, NIOSH offers the following recommendations to reduce the risk of on-the-job heart attacks and sudden cardiac arrest among fire fighters at this, and other, fire departments across the country.

Provide mandatory pre-placement and period medical evaluations to all fire fighters consistent with the National Fire Protection Association (NFPA) Standard 1582, Standard on Comprehensive Occupational Medical Program for Fire Departments.

- 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 clearance to wear self-contained breathing apparatuses (SCBAs) as part of the fire department's medical evaluation program.
- Develop a comprehensive wellness/fitness program for fire fighters to reduce risk factors for cardiovascular (CVD) and improve cardiovascular capacity.

INTRODUCTION & METHODS

On May 06, 2007, a 54-year-old male volunteer FF collapsed while performing exterior fire suppression at a large machine shed fire. Despite on scene CPR and defibrillation attempts, followed by advanced life support in the ambulance and hospital emergency department, the FF died. NIOSH was notified of this fatality on May 8,

2007, by the United States Fire Administration. NIOSH contacted the affected fire department shortly thereafter to obtain further information, and again on June 20, 2008, to schedule the investigation. On June 25, a contractor for the NIOSH Fire Fighter Fatality Investigation Team (the NIOSH investigator) conducted an on-site investigation of the incident.

During the investigation, the NIOSH investigator interviewed the following people:

- Assistant Fire Chief
- Crew members working with the FF on the day of the incident
- FF's personal physician
- FF's spouse
- The NIOSH investigator reviewed the following documents in preparation of this report:
- Fire department incident report
- Crew members' statements
- Dispatch records
- Ambulance report
- Death certificate
- Autopsy
- Primary care physician's medical records
- Hospital records
- FF training records

INVESTIGATIVE RESULTS

Incident Response. On May 6, 2007, the FF responded to a structure fire in a large machine shed (approximately 40 x 60 ft) that contained farm equipment. This was the FF's first response to a fire call over the previous 24 hours. The FF responded in his personal vehicle and arrived on scene at approximately 1040 hours. It was a warm (approximately 70 ° Fahrenheit) day with winds blowing out of the southeast at approximately 15-20 mph.

The machine shed was fully involved when the FF arrived and several pieces of farm equipment were burning inside the shed. He donned his PPE, including coat and bunker pants, but did not wear an SCBA. The FF worked an exterior attack hose line (1¾") to help extinguish the fire in the machine shed and to protect a nearby structure for approximately 20 minutes. The FF was on the nozzle the entire time he was working the attack line with assistance from other firefighters. When he was in position to operate the attack line he knelt on one knee and directed the water to the structure. It is estimated that the work involved in pulling the hose into position and moving the charged line represented "moderate" physical activity (about 7-9 metabolic equivalents [METS]) [Glenhill 1991]. Some crew members offered to relieve the FF, but he refused. During the suppression effort, EMS personnel provided bottled water for hydration and they noted the FF interacted in a normal manner. The EMS personnel who provided water to the FF was not in bunker gear and reported that the FF was not close enough to the fire to be subject to much radiant heat

from the fire as he was operating the attack line. A short time after receiving a bottle of water, the FF suddenly collapsed.

Fire fighters assisting with the hose line, and others nearby, immediately pulled him away from the involved structure. An EMT who was near the FF when he collapsed, found the FF unresponsive, not breathing, and without a pulse. He immediately started CPR.

An AED was retrieved from a nearby ambulance and attached to the FF. The defibrillator advised that a shock be given and this was delivered without a change in his heart rhythm. A second defibrillation was advised and administered. Again, this did not change the FF's clinical condition. The FF was loaded into the ambulance and transported to the hospital with CPR being continually administered.

An advanced life support ambulance met the ambulance transporting the FF approximately 5 minutes after it left the scene and a paramedic joined the original ambulance crew during the last 6 minutes of transport. During the remainder of the transport the monitor showed the FF to be in ventricular fibrillation (a heart rhythm incompatible with life). The FF was defibrillated three more times en route to the hospital with no change in the FF's heart rhythm. During transportation, ALS trained personnel were unable to intubate the FF (insert a breathing tube into the FF's trachea), nor were they able to start an intravenous (IV) line. Oxygen was administered and CPR (assisted by bag-valve mask) was continued throughout the transport.

The ambulance arrived at the Emergency Department at 1130 hours. At this point the FF was unresponsive with pupils fixed and dilated and without a pulse for about 25 minutes. Advanced life support protocols were followed but the FF could not be revived. The FF was pronounced dead at 1147 hours, approximately 42 minutes after his collapse.

Medical Findings. The death certificate, completed by the Medical Examiner, listed "Coronary Atherosclerosis" as the cause of death. Pertinent findings from the autopsy, performed by a Forensic Pathologist, on May 7, 2007, include the following:

- Mildly enlarged heart at 420 grams (normal being typically <400 grams)
- Atherosclerotic coronary artery disease
  - — A 2.0 centimeter segment of the left anterior descending artery with a 80-90% blockage
  - — A 50% blockage of the posterior descending artery
- No pulmonary embolus (no blood clot in the pulmonary artery)
- No soot deposition in the airway
- Negative toxicology report for alcohol and drugs
- Carbon monoxide negative

Prior to this episode, the FF was in good health and rarely visited his primary care physician. He routinely engaged in heavy physical labor,

did not smoke, was only slightly overweight with a body mass index of 25.8 (normal BMI 20-25.0) [CDC 2008]. In 2002, the FF's primary care physician ordered a blood test to check his cholesterol level because of his family history of high blood cholesterol, but the FF never had the blood test done. The FF was a commercial airplane pilot (he worked as a self-employed crop duster) and in March 2007 passed an annual medical examination to receive a 2nd class medical certificate required by the Federal Aviation Administration (FAA) to maintain his pilot's license. During this medical examination the FF had a blood pressure reading of 132/76 millimeters of mercury (mmHg) and a pulse of 70 beats per minute. There was no significant medical history provided by the FF and the examining physician found no abnormal findings. According to his wife the FF had no complaints of angina (chest pain) or any other symptoms suggestive of heart problems.

DESCRIPTION OF THE FIRE DEPARTMENT

At the time of the NIOSH investigation, the fire department had 31 personnel. It has a single fire station and serves a population of approximately 1,600 residents and covers an area of approximately 60 square miles. The fire department responded to 125 calls in 2006. The calls were distributed as follows: structure fires (7), brush fires (3), vehicle fires (4), rescue (22), EMS (82), mutual aid (4), man call box (1), and false alarms (2).

Training. The fire department requires new members to complete a one year apprenticeship. During that period, fire fighters are required to:

- obtain a drivers license to operate the fire department equipment,
- complete a specially written examination on basic firefighting material and information specific to the department,
- attend monthly meetings, and
- participate in "hands-on" training provided by the fire department.

The fire department pays fire fighters to take training classes offered by neighboring fire departments or with the State Training Academy. The FF was a Certified Fire Fighter II and had received additional training in auto extrication. He had been a FF with the fire department for 22 years.

Pre-placement Medical Evaluations. The fire department requires that new members receive a medical examination within 60 days of becoming an apprentice. The fire department pays for the medical examination but there is no prescribed content for the examination nor is there a specific fitness-for-duty form to be completed. The FF joined the fire department in 1985 when no pre-placement medical evaluation was required. In 1990, the FF provided a statement indicating that he believed himself to be in satisfactory physical condition to perform all duties assigned to him as a volunteer firefighter. At that time, a departmental blood

pressure check was performed and his blood pressure was recorded as 120/70mmHg.

Periodic Medical Evaluations. The fire department does not require periodic medical evaluations for fire fighters. Medical clearance for SCBA use is not required. There is no formal procedure for clearing fire fighters back to work if they are injured or suffer a serious illness. As mentioned earlier, the FF passed his FAA required medical evaluation to maintain his pilot's license.

Fitness/Wellness Programs. There is no organized fitness or wellness program offered by the department.

DISCUSSION

CAD and the Pathophysiology of Sudden Cardiac Death. This FF suffered a cardiac arrest and sudden cardiac death. The most common risk factor for cardiac arrest and sudden cardiac death is coronary artery disease (CAD), defined as the build-up of atherosclerotic plaque in the coronary arteries [AHA 2008]. The FF was found to have CAD at autopsy in the form of a single, high grade lesion (80-90% blockage) in one of the most important coronary arteries (the left anterior descending artery). Risk factors for CAD development include increasing age, male gender, family history of CAD, smoking, hypertension, high blood cholesterol, obesity/physical inactivity, and diabetes [Libby 2005]. The FF was a male over 45 years of age, but had no other known risk factors (he did have a family history of high blood cholesterol but, according to medical records available to NIOSH at the time of this report, he never had his blood cholesterol checked). The narrowing of the coronary arteries by atherosclerotic plaques occurs over many years, typically decades [Libby 2005]. However, the growth of these plaques probably occurs in a nonlinear, often abrupt fashion [Shah 1997]. Most heart attacks occur when a vulnerable plaque ruptures, causing a blood clot to form which occludes a coronary artery. At autopsy, no evidence was found for old, or an acute, heart attack. Establishing the occurrence of an acute heart attack requires any of the following: characteristic electrocardiogram (EKG) changes, elevated cardiac enzymes, or coronary artery thrombus/plaque rupture. In the FF's case, he never regained a heart rhythm on which an EKG could reveal characteristic changes, cardiac enzyme testing was not performed (but we would not expect the enzymes to become positive for at least 4 hours post-heart attack), and no coronary artery blood clot/plaque rupture was found at autopsy. However, occasionally (16-27% of the time) post-mortem examinations do not reveal the coronary artery blood clots/plaque rupture during acute heart attacks [Davies 1992; Farb 1995]. Despite the FF's lack of chest pain (angina), the clinical scenario of this FF's death is most consistent with a heart attack [Libby 2005; Thaulow 1993].

The FF collapsed during exterior fire suppression. Firefighting is widely acknowledged to be physically demanding. Firefighting activities are physically taxing and often require fire fighters to work at near maximal heart rates for

long periods. The increase in heart rate typically occurs in response to the initial alarm and persists through the course of fire suppression activities [Barnard1975; Lemon1977; Manning 1983; Smith 2001]. 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 [Smith 1995].

Epidemiologic studies in the general population have found that heavy physical exertion can trigger a heart attack and cause sudden cardiac death [Tofler 1992; Willich 1993; Mittleman 1993; Albert 2000]. Epidemiologic studies among fire fighters have shown that fire suppression, training, alarm response, or strenuous physical activity on the job in the preceding 12 hours, increases the risk for a sudden cardiac event [Kales 2003; Hales 2007; Kales 2007]. The FF was involved in alarm response and in moderate physical activity during his exterior fire suppression.

Based on the findings discussed above, the NIOSH investigator concluded that the FF died from a probable heart attack possibly triggered by responding to the fire alarm and performing moderate physical exertion at the fire scene.

Occupational Medical Standards for Structural Firefighting 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 NFPA 1582 [NFPA 2007]. NFPA 1582 recommends diagnostic screening for CAD via an exercise stress test for asymptomatic fire fighters over age 45 (55 for women) with two or more risk factors for CAD (family history of premature cardiac event, hypertension, diabetes mellitus, cigarette smoking, and hypercholesterolemia). This recommendation is consistent with recommendations from the AHA/ACC [2002] and the Department of Transportation [1987] regarding exercise stress tests in asymptomatic persons. Because the FF did not have any of the CAD risk factors listed above, an exercise stress test would not have been indicated by either NFPA or the American Heart Association/American College of Cardiology. Thus, even if this fire department was following NFPA standards, it is unclear if his death could have been prevented at this time.

RECOMMENDATIONS

It is unclear if any of the following recommendations could have prevented the death of this FF at this time. Nonetheless, NIOSH offers these recommendations to reduce the risk of on-the-job heart attacks and sudden cardiac arrest among fire fighters at this, and other, fire departments across the country.

Recommendation #1: Provide mandatory annual medical evaluations to all fire fighters consistent with NFPA 1582 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 periodic medical evaluations and examinations for fire fighters can be found in NFPA 1582 and in the International Association of Fire Fighters/International Association of Fire Chiefs (IAFF/IAFC) Fire Service Joint Labor Management Wellness/Fitness Initiative [NFPA 2007; IAFF 2000]. The fire department, however, is not legally required to follow this standard or this initiative.

This recommendation has financial implications and may be particularly difficult for small, volunteer fire departments to implement. The fire department may have to consider alternative options to overcome the financial obstacle. One option urges 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. Additional suggestions for overcoming the financial burden of implementing medical examinations within the volunteer service 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 [National Volunteer Fire Council 2004].

Recommendation #2: 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.

Physicians who provide input regarding medical clearance for firefighting duties should be knowledgeable about the unique physical demands of firefighting that result from the combination of strenuous physical work, heavy and encapsulating personal protective ensembles, extreme ambient temperatures, and emotional stress. Physicians should also be familiar with a fire fighter's personal protective equipment and the consensus guidelines published by NFPA 1582 [NFPA 2007].

Recommendation #3: Provide fire fighters with medical clearance to wear self-contained breathing apparatuses (SCBAs) as part of the fire department's medical evaluation program.

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 [CFR 1998]. Such employees include fire fighters who use

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 does not operate an OSHA-approved State plan; therefore, public sector employers are not required to comply with OSHA standards [US Department of Labor 2006]. Nonetheless, we recommend following this standard to ensure fire fighters are medically able to wear SCBA.

Recommendation #4: Develop a wellness/fitness program for fire fighters to reduce risk factors for CVD 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 an independent risk factor for CAD and it is positively associated with other risk factors including, obesity, dyslipedemia and diabetes [Plowman and Smith 2003]. NFPA 1500 requires a wellness program that provides health promotion activities for preventing health problems and enhancing overall well-being [NFPA 2002]. Guidance for how to implement and components of a wellness and fitness program can be found in several documents provided by Fire Service organizations:

- NFPA 1583, Standard on Health-Related Fitness Programs for Fire Fighters [NFPA 2000];
- International Association of Fire Fighters/International Association of Fire Chiefs (IAFF/IAFC), Fire Service Joint Labor Management Wellness/Fitness Initiative [NFPA 2007];
- National Volunteer Fire Council (NVFC) / United State Fire Administration (USFA) Health and Wellness Guide for the Volunteer Fire Service [National Volunteer Fire Council 2004].

Implementing a Health and Wellness program is a particular challenge for small, volunteer fire departments. Forming effective partnerships (with park districts, fitness clubs, clinics) and capitalizing on the camaraderie of the fire service may help address these issues.

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INVESTIGATOR INFORMATION

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F2008-20 Volunteer Fire Fighter Dies While Performing Exterior Fire Suppression at a Large Machine Shed Fire - Illinois

The National Institute for Occupational Safety and Health (NIOSH), an institute within the Centers for Disease Control and Prevention (CDC), is the federal agency responsible for conducting research and making recommendations for the prevention of work-related injury and illness. In fiscal year 1998, the Congress appropriated funds to NIOSH to conduct a fire fighter initiative. NIOSH initiated the Fire Fighter Fatality Investigation and Prevention Program to examine deaths of fire fighters in the line of duty so that fire departments, fire fighters, fire service organizations, safety experts and researchers could learn from these incidents. The primary goal of these investigations is for NIOSH to make recommendations to prevent similar occurrences. These NIOSH investigations are intended to reduce or prevent future fire fighter deaths and are completely separate from the rulemaking, enforcement and inspection activities of any other federal or state agency. Under its program, NIOSH investigators interview persons with knowledge of the incident and review available records to develop a description of the conditions and circumstances leading to the deaths in order to provide a context for the agency's recommendations. The NIOSH summary of these conditions and circumstances in its reports is not intended as a legal statement of facts. This summary, as well as the conclusions and recommendations made by NIOSH, should not be used for the purpose of litigation or the adjudication of any claim. To request additional copies of this report (specify the case number shown in the shield above), for other fatality investigation reports, or further information, visit the Program Website at

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