



Deputy Chief Suffers Unwitnessed Sudden Cardiac Death While Fighting a Wildland Fire in Steep Terrain - Massachusetts

SUMMARY

On April 8, 1999, a 64-year-old male Deputy Chief of a paid call fire department was the first responder to a wildland fire in mountainous terrain. His initial assessment prompted him to request assistance from neighboring departments and from the State Air National Guard. Fire investigators determined that the fire was started by sparks from an abrasive saw that railroad employees were using during track repair. Fire authorities stated that similar railroad maintenance activities are a common cause of wildland fires. High winds and drought-like conditions rapidly contributed to the spread of this fire. The victim engaged in fire suppression activities for over 4 hours prior to his unwitnessed collapse. The victim was down for approximately 10 - 15 minutes when another fire fighter found him unconscious, without a pulse or respirations, on the ground next to a fire truck. The victim died despite cardiopulmonary resuscitation (CPR) and basic life support (BLS) administered by fellow firefighters and emergency medical technicians (EMTs) at the scene, and advanced life support (ALS) administered by paramedics and hospital emergency department personnel. Autopsy findings included "coronary atherosclerosis, focally severe," "extensive fibrosis in the antero-septal region of the left ventricle," "left ventricular hypertrophy," and "chronic obstructive pulmonary disease."

Other agencies have proposed a three-pronged strategy for reducing the risk of on-duty heart attacks and cardiac arrests among fire fighters. This strategy consists of (1) minimizing physical stress on fire fighters; (2) screening to identify and subsequently rehabilitate high-risk individuals; and (3) encouraging increased individual physical capacity. Recommendations relevant to this fire department include the following:

- *Provide fire fighters with medical evaluations to determine their medical ability to perform duties without presenting a significant risk to the safety and health of themselves or others.*
- *Initiate a wellness/fitness program for fire fighters to reduce risk factors for cardiovascular disease and improve cardiovascular capacity.*

Additionally, a recommendation for wildland fire prevention is included:

- *Fire officials and railroads should voluntarily (a) jointly review and/or establish protocols and procedures to prevent the occurrence of fires caused by railroad work activities, and (b) prepare and/or implement a system for notification of fire officials of railroad work activities that pose a fire risk.*

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. 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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INTRODUCTION & METHODS

On April 8, 1999, a 64-year-old male Deputy Chief of a paid call fire department was found in cardiac arrest at the scene of a wildland fire. The victim died despite CPR and BLS administered by fellow firefighters and EMTs at the scene and ALS administered by paramedics and hospital emergency department personnel. NIOSH was notified of this fatality on April 12, 1999, by the United States Fire Administration. On July 27, 1999, NIOSH contacted the affected fire department to initiate the investigation. On September 1, 1999, a Nurse Epidemiologist and an Industrial Hygienist from the NIOSH Fire Fighter Fatality Investigation and Prevention Team traveled to Massachusetts to conduct an onsite investigation.

During the investigation NIOSH personnel met with and/or interviewed the

- State Fire Marshal
- Fire Chief
- Victim's spouse and son
- Acting Deputy Fire Chief
- Fire Fighters from this department
- Fire Department's dispatcher
- Fire Fighting personnel from departments providing mutual aid for this incident
- Medical/Service Director and Emergency Medical Service (EMS) Coordinator

During the site visit NIOSH personnel also reviewed

- Massachusetts State Police Investigative Report, including witness statements, scene examination, and summary report

- Fire Department personnel and medical records
- Fire Department dispatch records
- Fire Department policies, training, and operating procedures
- Emergency medical services—ambulance reports
- Hospital emergency department (ED) records of the resuscitation effort
- Hospital records from a previous visit
- Personal physician medical records
- Death certificate
- Autopsy results
- State Department of Environmental Management and National Weather Service reports for incident date

INVESTIGATIVE RESULTS

Incident Response. At approximately 1200 hours on April 8, 1999, a fire was ignited by sparks generated from a 16-inch abrasive saw being used by a railroad work crew during track repair. A Massachusetts State Police investigation included a statement by the person who performed the rail cutting which stated that the use of the abrasive saw had ignited this fire, as well as previous fires. (During a 48-hour period preceding this incident, local fire departments responded to 19 fires which were started by railroad maintenance work along approximately 8 miles of track.)

The crew attempted to extinguish the fire using a 5-gallon water can, a fire extinguisher and a water



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cooler. These attempts were unsuccessful due to the extremely dry brush and high winds. These workers retreated to safety, and at 1218 hours Regional Dispatch received a 911 telephone call from a railroad company employee reporting an uncontrolled brush fire. At 1219 hours, the paid call department was toned out, and within 1-minute, the Deputy Chief (the victim) responded. While en route to the fire station, the Deputy Chief observed the location and extent of the wildland fire. At 1226 hours he arrived at the fire station, and he immediately requested assistance from two neighboring towns. By 1238 hours, two engines were en route (one from the victim's department, and one from the neighboring town). The Deputy Chief arrived on scene at 1256 hours and had two engines at his command by 1258 hours. The Deputy Chief, recognizing the danger posed by the wind-driven flames which were enveloping the steep terrain, known locally as "the mountain," called the State Air National Guard to request an air attack. The Air National Guard was initially unable to respond due to extremely windy (40-mile-per-hour) conditions. At 1400 hours, incident command was transferred from the Deputy Chief to the Chief, who had arrived at the scene. Shortly after 1400 hours, the standard operating procedure for mutual aid was implemented, and the Chief ordered mutual aid units to defend a neighboring community. By 1400 hours, EMS established mobile rehydration and rehabilitation units for fire fighters. In total, 80 fire fighters from 42 departments (and the Air National Guard) responded to this wildland fire, which took 2 days to suppress.

During his 4 hours of fire suppression activities, the Deputy Chief worked alongside two other fire fighters assigned to a brush truck on a logging road. His activities involved cutting trees, connecting additional hose lines, pumping water, and surveying the area where fires were erupting and spreading over the mountain. The Deputy Chief, like the other fire fighters, wore prescribed protective equipment for

wildland fires (eye protection, bump helmet, gloves, dungarees, and leather boots). Throughout the afternoon, the Deputy Chief and other fire fighters often had to retreat to safety as frequent wind shifts drove the flames toward them.

At approximately 1720 hours, the Deputy Chief told one of the fire fighters that additional hose was needed at another location. The fire fighter offered to take the hose and suggested that the Deputy Chief take a break and monitor the truck and pump. After approximately 15 minutes, the fire fighter returned to the truck where he found the Deputy Chief collapsed on the ground next to the truck. The fire fighter found no pulse and noted that the Deputy Chief was cyanotic. He initiated CPR and radioed for assistance at 1736 hours. Within minutes three fire fighters responded to the call and took over CPR. An EMT/fire fighter inserted an oral-pharyngeal airway, and bag valve mask ventilation was added to resuscitative efforts. A BLS ambulance was dispatched immediately; however, the ambulance was too top-heavy to be driven into this terrain. Therefore, the victim was placed on a scoop stretcher and lifted into the bed of the Chief's pickup truck. CPR was continued, and at 1751 hours an automatic external defibrillator (AED) was applied during transport to the waiting ambulance. Three "no shock" advisories were reported at 1751, 1752, and 1753 hours. CPR was continued, and at 1757 hours, the victim was transferred to the waiting BLS ambulance. An AED reassessment was performed and a shock advisory was noted; 200 joules were delivered, but no pulse or heart rhythm resulted. At 1758 hours, an ALS ambulance intercepted, and ALS paramedics boarded the BLS ambulance. An intravenous line (IV) was started at 1802 hours and a sequence of cardiac medications was administered. The victim was also intubated. All electrocardiogram (EKG) monitoring indicated asystole (no heart beat).



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The victim arrived at the local ED at 1815 hours, and he was noted to be apneic, pulseless, and asystolic. In the ED, he received a single round of IV cardiac medications (without response) with CPR in progress. ED personnel confirmed good positioning of his endotracheal tube with 100% oxygen-assisted ventilation. At 1817 hours the victim was pronounced dead, and resuscitation efforts were discontinued.

Medical Findings. The death certificate was completed by the Medical Examiner, who listed “coronary atherosclerosis” (which was indicated to be chronic) as the immediate cause of death, with “chronic obstructive pulmonary disease” being an “other significant condition contributing to [the] death.” Significant findings from the autopsy performed by the Medical Examiner included

1. coronary atherosclerosis, focally severe
 - 90% occlusion of the left coronary artery
 - 50% occlusion of the right coronary artery
 - extensive fibrosis in the anterior, antero-septal region of the left ventricle
 - palpable calcification of all coronary arteries
2. left ventricular hypertrophy
3. chronic obstructive pulmonary disease

At autopsy the carboxyhemoglobin level was less than 5%, suggesting that carbon monoxide exposure was not the cause of his death.

The victim’s last visit to a physician, approximately 5 years before his death, was for laryngitis and did not include any cardiology workup. In 1992, the victim was approved to wear a respirator for his regular job, at which time his resting EKG and blood pressure were normal. Family members and colleagues reported that the victim did not exercise regularly but was not overweight. He had never reported symptoms suggestive of heart disease at home, during leisure activities, while performing his

job as an electrician, or while performing Deputy Chief Officer duties. He had no family history of coronary artery disease (CAD). He had stopped cigarette smoking 22 years ago. The morning of the wildland fire, while at his regular job from 0730 to 1200 hours, the victim did not complain of chest pain, shortness of breath, dizziness, or any other symptom suggestive of cardiac problems.

DESCRIPTION OF THE FIRE DEPARTMENT

At the time of the NIOSH investigation, the fire department consisted of 35 paid call fire fighters who serve a population of 1,600 in a geographic area of 17 square miles. The department operates two fire stations. One station, located in town, is equipped with two engines, an attack tanker, one light rescue vehicle, and a brush truck. The second station, located approximately 8 miles away, is equipped with a 1,200-gallon pumper tanker. When paged by dispatch, fire fighters obtain appropriate fire fighting equipment at the stations. When dispatched to a structural fire, all vehicles except the brush truck respond. When dispatched to a wildland fire, all vehicles respond except one backup engine, which remains to answer any additional calls. However, if needed in a wildland fire, this engine may also be dispatched.

For the past 10 years this department has averaged approximately 100 calls annually. These calls are classified as 50% EMS responses, 30% fires, and 20% investigative.

Emergency medical services are directed by the fire department and an independent ambulance service. Ambulance services provide basic life support response, and EMS ambulances are equipped with trauma kits, oxygen, defibrillators, and full spinal immobilization equipment. An ALS ambulance from a neighboring fire department, which responds to all



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requests from this community, is equipped with all of the above equipment plus an ALS drug kit, cardiac monitor, and intubation kit.

Training. The fire fighters in this department are trained as First Responders. Fire fighting training is performed by a full-time career fire fighter (the current Acting Deputy Chief), who is also an instructor at the Massachusetts Firefighting Academy. Although the victim was not a National Fire Protection Association (NFPA) certified fire fighter, he had 30 years of fire fighting experience and was a certified wildland fire fighter.

Preemployment/Preplacement Evaluations. As required by State law since 1996, the department requires a preemployment/preplacement medical evaluation for all new paid call positions. Mandatory components of this evaluation for all applicants will include

- A complete medical history (to include an occupational history with significant past exposures and training and experience with personal protection equipment)
- Height, weight, and vital signs
- Physical examination (of the skin, ears, eyes, nose, throat, mouth, mental status evaluation, and the following systems: cardiovascular, respiratory, gastrointestinal, genitorurinary, musculoskeletal, neurologic, endocrine, and metabolic)
- Vision test (acuity and peripheral vision)
- Hearing test (audiometry)
- Pulmonary function testing
- Other diagnostic tests where indicated

Optional components of this evaluation include the following:

- Review of tetanus and hepatitis B immunization status
- PPD test (skin test for tuberculosis)

- Five-panel drug test
- Urine dipstick
- Chest x-ray
- Electrocardiogram
- Complete blood count
- Chemistry panel (20 items)

No new fire fighters have joined the department since this law came into effect; however, plans are in progress to have these evaluations performed by a local emergency medicine physician.

Periodic Evaluations Annual/periodic medical evaluations are not required by this Department. For employees hired after 1996, the State requires a biannual physical ability test (PAT). Prior to taking the PAT, the State recommends, but does not require, that each individual complete a “physical activity readiness questionnaire.” This self-administered questionnaire, composed of seven questions, is intended to identify “the small number of adults for whom physical activity might be inappropriate and those who should have medical clearance prior to exercise and testing.” As mentioned above, no new fire fighters have joined the department since this law came into effect. No voluntary or required fitness/wellness program exists, nor is periodic medical clearance for SCBA use required.

DISCUSSION

In the United States, coronary artery disease (atherosclerosis) is the most common risk factor for cardiac arrest and sudden cardiac death.¹ Risk factors for its development include increasing age (greater than 45 years old for men), male gender, family history of coronary artery disease, smoking, high blood pressure, high blood cholesterol, obesity/physical inactivity, and diabetes.² The victim had three of these risk factors: age greater than 45 years old, male gender, and lack of conditioning physical activity.



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The narrowing of the coronary arteries by atherosclerotic plaques occurs over many years, typically decades.³ However, the growth of these plaques probably occurs in a nonlinear, often abrupt fashion.⁴ 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.⁵ This sudden blockage is primarily due to blood clots (thrombosis) forming on the top of atherosclerotic plaques.

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 persist through the course of fire suppression activities.⁶⁻⁸ Epidemiologic studies have found that heavy physical exertion sometimes immediately precedes and triggers the onset of acute heart attacks.⁹⁻¹² The physically demanding job of laying, pulling, and organizing charged supply and attack hoses, the lack of manpower, the mental stress of initially responding to the emergency as the incident commander and his previously undiagnosed atherosclerotic coronary artery disease all probably contributed to this victim's sudden cardiac death.

This victim did not report prior episodes of angina (heart pain) during physical activity performed on or off the job. Sudden cardiac death is often the first overt manifestation of ischemic heart disease.¹³ This fatality occurred despite appropriate CPR and ALS efforts. CPR was initiated immediately after the victim was found, but cardiac arrest could have occurred as much as 15 minutes earlier.

The fire department has not had the occasion to implement the State's required preemployment/preplacement medical evaluation and biannual PAT. It should be pointed out that discrepancies exist between the frequency and content of the State-required medical evaluation and the medical

evaluation recommended by the NFPA.¹⁴ The most significant discrepancy is found in the annual/periodic evaluation. For example, the State only requires a self-completed questionnaire to identify individuals who may need further medical evaluation prior to initiating a PAT. NFPA, on the other hand, recommends that a physician conduct annual medical evaluations on all fire fighters regardless of age. These evaluations consist of (1) an update of the fire fighter's medical history (including any significant changes, a brief review of symptoms, and a report on any significant job-related exposures experienced during the past year), (2) height and weight, (3) visual acuity, (4) blood pressure, and (5) any additional testing depending on the fire fighter's medical condition.

NFPA also recommends a more thorough evaluation, including a medical examination, be conducted on a periodic basis depending on the age of the fire fighter. For individuals less than 30 years of age, every 3 years; for those 30-39, every 2 years; and for those 40 and over, every year. The recommended content of this evaluation includes (1) an updated medical and interval history, (2) complete physical examination, (3) vision testing, (4) audiometry, (5) pulmonary function testing, (6) complete blood count, (7) urinalysis, (8) biochemical (blood) test battery, and (9) exercise stress (treadmill) tests. The NFPA recommends stress tests at least every 2 years for those 35 years old and above with known CAD risk factors and for everyone 40 years old and above. This exercise stress testing procedure has errors both in over-diagnosis and in under-diagnosis, although newer techniques, including the use of thallium administration or additional monitoring, can improve the accuracy of the procedure.¹⁵ It is thus possible that asymptomatic fire fighters could have coronary artery disease detected before an event such as a myocardial infarction occurred.¹⁶ If a treadmill test had been performed on this Officer, his underlying CAD may have been identified, and he could have been directed toward further evaluation and treatment.



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RECOMMENDATIONS AND DISCUSSION

The following recommendations address health and safety generally. This list includes some preventive measures that have been recommended by other agencies to reduce the risk of on-the-job heart attacks and sudden cardiac arrest among fire fighters. These recommendations have not been evaluated by NIOSH but represent research presented in the literature or consensus votes of Technical Committees of NFPA or labor/management groups within the fire service. Additionally, a recommendation for wildland fire prevention is provided.

Recommendation #1: Provide fire fighters with medical evaluations to determine their medical ability to perform duties without presenting a significant risk to the safety and health of themselves or others.

The Department is not currently following the mandatory components of the State-required preemployment/preplacement examination; however, preliminary plans are in place to do so. As noted, there have been no new applicants since this law came into effect. The Department is not conducting any annual/periodic medical evaluations as recommended by NFPA. Guidance regarding the content and scheduling of periodic medical examinations for fire fighters can be found in *NFPA 1582, Standard on Medical Requirements for Fire Fighters*,¹⁴ and in the report of the International Association of Fire Fighters/International Association of Fire Chiefs wellness/fitness initiative.¹⁷

In addition to providing guidance on the frequency and content of the medical evaluation, NFPA 1582 provides guidance on medical requirements for persons performing fire fighting tasks. Applying NFPA 1582 involves legal issues, so it should be carried out in a **confidential, nondiscriminatory** manner. Appendix D of NFPA 1582 provides

guidance for fire department administrators regarding legal considerations in applying the standard.

Applying NFPA 1582 also involves economic issues. These economic concerns go beyond the costs of administering the medical program; they involve the personal and economic costs of dealing with the medical evaluation results. *NFPA 1500, Standard on Fire Department Occupational Safety and Health Program*, addresses these issues in Chapter 8-7.1 and 8-7.2.¹⁸

The success of medical programs hinges on protecting the affected fire fighter. The department must (1) keep the medical records confidential, (2) provide alternate duty positions for fire fighters in rehabilitation programs, and (3) if the fire fighter is not medically qualified to return to active fire fighting duties, provide permanent alternate duty positions or other supportive and/or compensated alternatives. These legal and economic repercussions **may be particularly difficult for small, paid call fire departments**, such as the one involved in this incident, and could negatively impact the ability to recruit and retain needed fire fighters.

Recommendation #2: Initiate a 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.¹⁸ In 1997, the International Association of Fire Fighters and the International Association of Fire Chiefs 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



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to pool information about their physical fitness programs and to create a practical fire service program. They produced a manual with a video detailing elements of such a program.¹⁷ The Fire Department and the Union should review these materials to identify applicable elements for their department. Other city-negotiated programs can also be reviewed as potential models.

Recommendation #3: Fire officials and railroads should voluntarily (a) jointly review and/or establish protocols and procedures to prevent the occurrence of fires caused by railroad work activities; and (b) prepare and/or implement a system for notification of fire officials of railroad work activities that pose a fire risk.

Tinder-dry conditions resulted from a virtual lack of rain during the preceding 30 days. Data provided by the National Weather Service indicated that the total rain fall for the 30-day period prior to the fire was 0.05 inches. High winds in the area resulted in a "Red Flag" (most severe) fire warning from the State Department of Environmental Management. Nineteen separate fire department responses to extinguish fires caused by railroad crew maintenance preceded this fatal incident.

As a result of this fire, the State Fire Marshal and the Department's Chief have drafted state legislation which would require railroad(s) to notify local fire chiefs whenever the railroad plans to engage in open-flame work which is likely to cause a fire. This legislation would also allow fire chiefs to set conditions for proposed work, including limiting activities during periods of high fire danger, and the requirement of a fire department detail to provide oversight and assist in fire suppression. The act of drafting this legislation has resulted in positive dialogue between fire officials and the railroad company.

REFERENCES

1. Fauci AS, Braunwald E, Isselbacher KJ, et al. [1998]. Harrison's principles of internal medicine. 14th ed. New York, NY: McGraw-Hill, pp.222-225.
2. American Heart Association (AHA) [1998]. AHA scientific position, risk factors for coronary artery disease. Dallas, TX.
3. Fauci AS, Braunwald E, Isselbacher KJ, et al. [1998]. Harrison's principles of internal medicine. 14th ed. New York, NY: McGraw-Hill, p.1348.
4. Shah PK [1997]. Plaque disruption and coronary thrombosis: new insight into pathogenesis and prevention. Clin Cardiol 20 (11 Suppl2): II-38-44.
5. Fuster V, Badimon JJ, Badimon JH [1992]. The pathogenesis of coronary artery disease and the acute coronary syndromes. N Eng J Med 326:242-250.
6. Barnard RJ, Duncan HW [1975]. Heart rate and ECG responses of fire fighters. J Occup Med 17:247-250.
7. Manning JE, Griggs TR [1983]. Heart rate in fire fighters using light and heavy breathing equipment: simulated near maximal exertion in response to multiple work load conditions. J Occup Med 25:215-218.
8. Lemon PW, Hermiston RT [1977]. The human energy cost of fire fighting. J Occup Med 19:558-562.
9. Willich SN, Lewis M, Lowel H, et al. [1993]. Physical exertion as a trigger of acute myocardial infarction. N Eng J Med 329:1684-1690.
10. Mittleman MA, Maclure M, Tofler GH, et al. [1993]. Triggering of acute myocardial infarction by



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- heavy physical exertion. *N Eng J Med* 329:1677-1683.
11. Siscovick DS, Weiss NS, Fletcher RH, Lasky T [1984]. The incidence of primary cardiac arrest during vigorous exercise. *N Eng J Med* 311:874-877.
12. Tofler GH, Muller JE, Stone PH, et al. [1992]. Modifiers of timing and possible triggers of acute myocardial infarction in the Thrombolysis in Myocardial Infarction Phase II (TIMI II) Study Group. *J Am Coll Cardiol* 20:1049-1055.
13. Fauci AS, Braunwald E, Isselbacher KJ, et al. [1998]. *Harrison's principles of internal medicine*. 14th ed. New York, NY: McGraw-Hill, p.1366.
14. National Fire Protection Association [1997]. NFPA 1582: standard on medical requirements for fire fighters. Quincy, MA: National Fire Protection Association.
15. Michaelides AP, Psomadaki ZD, Dilaveris PE, et al. [1999]. Improved detection of coronary artery disease by exercise electrocardiography with the use of right precordial leads. *New Eng J Med* 340:340-345.
16. Gianrossi R, Detrano R, Mulvihill D, et al. [1989]. Exercise-induced ST depression in the diagnosis of coronary artery disease: a meta-analysis. *Circulation* 57:64-70.
17. International Association of Fire Fighters [1997]. *The fire service joint labor management wellness/fitness initiative*. Washington, DC: International Association of Fire Fighters, Department of Occupational Health and Safety.
18. National Fire Protection Association [1997]. NFPA 1500: standard on fire department occupational safety and health program. Quincy, MA: National Fire Protection Association.

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