



Fire Fighter Suffers Fatal Heart Attack After Returning Home from Fire - Iowa

SUMMARY

On April 2, 2001, a 38-year-old male volunteer fire fighter was driving to work after returning home from a structural fire. He apparently passed out at an intersection, and his vehicle rolled across the road and into a fence. Police arrived approximately 3 minutes later, and the fire department and ambulance followed shortly. Despite cardiopulmonary resuscitation (CPR) and advanced life support (ALS) performed at the scene, in the ambulance, and at the hospital emergency department, and additional procedures in the hospital's cardiac catheterization laboratory, the fire fighter died. Based on autopsy findings, the death certificate, completed by the Medical Examiner, listed "Acute Myocardial Infarction" as the immediate cause of death and "Severe Arteriosclerotic Coronary Vascular Disease - Right Coronary Artery" as the underlying cause.

The following recommendations address some general health and safety issues identified during this investigation. 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 selected recommendations have not been evaluated by NIOSH, but are derived from published research, consensus votes of technical committees of the National Fire Protection Association (NFPA), or reports from fire service labor/management groups.

- *Expand the periodic medical evaluation program to conform to the recommendations of the National Fire Protection Association (NFPA) Standard 1582, Standard on Medical Requirements for Fire Fighters and Information for Fire Department Physicians. Depending on the fire fighter's age and*

coronary artery disease (CAD) risk factors, this program should incorporate exercise stress test (EST).

- *The medical decision regarding an ill or injured fire fighter returning to duty should be made by the physician providing occupational health services for the Fire Department.*
- *Phase in a mandatory wellness/fitness program for fire fighters to reduce risk factors for cardiovascular disease and improve cardiovascular capacity.*

INTRODUCTION AND METHODS

On April 2, 2001, a 38-year-old male fire fighter died after apparently passing out in his private vehicle while on his way to work after returning home from a fire call. On April 6, 2001, the United States Fire Administration notified NIOSH of the death. On October 1, 2001, NIOSH contacted the affected Fire Department to initiate the investigation. On November 1, 2001, a NIOSH contract physician traveled to Iowa to conduct an on-site investigation of the incident.

The **Fire Fighter Fatality Investigation and Prevention Program** is conducted by the National Institute for Occupational Safety and Health (NIOSH). The purpose of the program is to determine factors that cause or contribute to fire fighter deaths suffered in the line of duty. Identification of causal and contributing factors enable researchers and safety specialists to develop strategies for preventing future similar incidents. The program does not seek to determine fault or place blame on fire departments or individual fire fighters. To request additional copies of this report (specify the case number shown in the shield above), other fatality investigation reports, or further information, visit the Program Website at

www.cdc.gov/niosh/firehome.html
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People interviewed included

- The Fire Chief
- Crew members on duty with the deceased fire fighter
- A fire fighter friend not on duty with the deceased fire fighter
- The deceased fire fighter's spouse
- The deceased fire fighter's most recent physician and previous physician
- The Medical Examiner
- A (non-Fire Department) coworker

Documents reviewed included

- Fire Department policies and operating guidelines
- The deceased fire fighter's training records
- Fire Department annual report for 2000
- Fire Department medical evaluation records
- The deceased fire fighter's medical records maintained by his private physician
- Ambulance response report
- Hospital emergency department and cardiac catheterization laboratory records
- Fire Department incident reports
- Death certificate Autopsy report

INVESTIGATIVE RESULTS

Incident. On April 2, 2001, the affected fire fighter responded to a structural fire call received at 0635 hours. He drove Engine 1, which responded at 0641 and arrived at the scene at 0647 hours. The fire, in a small storage building at a cemetery, was controlled at 0710 hours, and Engine 1 left the scene at 0728. Engine 1 was parked about 200 feet from the burning structure, reportedly upwind, although one crew member said that there was initially smoke exposure at Engine 1's location. The temperature was above freezing, it was not raining or snowing, and there was melting snow (slush) on the ground. The affected fire fighter helped attach a hose between Engine 1 and Engine 3, helped stretch hose, and operated Engine 1's pump. Upon returning to the station, he helped return the engines to service (fill them with

water, clean them, and stow equipment). Accounts differ as to how long he was at the station, but he apparently left for home sometime before 0800 hours. Crew members noted his atypically abrupt departure but attributed it to his need to go to work. By the time he arrived home, family members had all left for the day. He called a coworker to say that he had been at a fire, that he was going to take a shower, and that he would be late for work.

At 0823 hours, 911 received a call from a business reporting that a vehicle (the deceased fire fighter's) had rolled across the road into a fence. The site was less than a minute's drive from the deceased fire fighter's home. Police responded at 0825 hours, removed the fire fighter from the essentially undamaged vehicle, and began cardiopulmonary resuscitation (CPR). The Fire Department and ambulance service were dispatched at 0825 hours; both arrived about 0830, the ambulance shortly before the Fire Department. Advanced life support (ALS) on the scene included endotracheal intubation, oxygen, intravenous medications, multiple attempts at cardioversion (external defibrillation) for ventricular fibrillation, and an attempt at external cardiac pacing. The ambulance departed the scene at 0846 and arrived at the hospital at 0857 hours. En route, the fire fighter regained a pulse for 1 to 2 minutes, but upon arrival in the emergency department, his heart had pulseless electrical activity (no effective heartbeat). ALS was continued, and at 0904 hours he regained a pulse and measurable blood pressure. At 0907 hours, he again lost his heartbeat, and ALS was resumed, including multiple attempts at cardioversion for ventricular fibrillation. The result of a blood test for carboxyhemoglobin (an indicator of carbon monoxide exposure) was reported as "0.0 %," but the blood was drawn almost 2 hours after Engine 1 departed the fire scene and after 50 minutes of oxygen (which accelerates the clearing of carboxyhemoglobin) administered via endotracheal tube. (At autopsy, the result of another



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carboxyhemoglobin test was also reported as “0.0 %.”) At 0936 hours, the fire fighter was taken to the cardiac catheterization laboratory, CPR continuing. Despite various diagnostic and therapeutic procedures, his heartbeat could not be restored, and he was pronounced dead at 1039 hours.

Medical Findings. Pertinent findings from the autopsy report, completed by the Medical Examiner, are listed below:

- Severe atherosclerotic coronary artery disease - distal right coronary artery”
- Remote myocardial infarctions. . . . One probably occurred months ago, and another is at least seven days in age.”
- Respiratory congestion and edema, severe.”

The Medical Examiner concluded that, “the presence of prior infarctions along with severe arteriosclerotic coronary disease suggests that the deceased suffered another acute myocardial infarction or had an arrhythmia.” On the death certificate, he recorded “Acute Myocardial Infarction” as the immediate cause of death and “Severe Arteriosclerotic Coronary Vascular Disease - Right Coronary Artery” as the underlying cause.

The deceased fire fighter was a dialysis technician. He never reported symptoms of CAD to his family or crew members. He smoked cigarettes and did not engage in regular physical exercise (except for home and yard work, and a leisurely walk once or twice a week). His father reportedly had two heart attacks, the first in his late 40s or early 50s.

The affected fire fighter spent the weekend before the fatal incident (which occurred Monday morning) at a vacation site with a fellow fire fighter and their families. He had a backache (a frequent problem for him) Saturday morning, but he reported no other symptoms and seemed normal the rest of the

weekend. Although he didn’t mention any symptoms at either the fire station or the fire scene, some crew members reported that he wasn’t as talkative and jovial as usual, and one reported that during a phone call the previous evening he said that he was tired and didn’t feel well. Two crew members thought he looked “gray” or “pale,” but others thought he looked normal. His coworker thought he sounded rushed, but otherwise normal, when he called in late for work. He responded to a fire call 8 days prior to the fatal incident and to two calls 8 days before that.

The deceased fire fighter’s only Fire Department medical evaluation was his preplacement evaluation in 1996. At that time, he weighed 274 pounds and had a slightly elevated blood cholesterol level. Hypertension (high blood pressure) was diagnosed in 1997. At the time of his death, he was taking medications to control his blood pressure and cholesterol. Since 1997, his blood glucose (sugar) levels were elevated, but not enough to warrant a diagnosis of diabetes. His last recorded weight, in June 2000, was 314 pounds. With a height of 74 inches (recorded in December 1997), his body mass index (BMI) in June 2000 was 40 kg/m². (A BMI above 30 kg/m² indicates obesity.¹) His most recent electrocardiogram (ECG), in February 1997, had minor abnormalities not diagnostic of CAD. There is no record of an EST.

DESCRIPTION OF THE FIRE DEPARTMENT

The Fire Department consists of 25 volunteer fire fighters. It serves a small city and surrounding rural area, with a total population of 12,000 residents in a geographic area of 98 square miles. There is one fire station. In 2000, the Department responded to 252 calls: 59 fires/explosions, 97 rescue calls (58 of which were medical), 31 hazardous conditions, 9 service calls, 22 good intent calls, and 34 false alarms. Calls for medical assistance are handled by a contract ambulance service, but the Fire



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Department responds if needed for rescue or if CPR is in progress.

Training. To qualify as a fire fighter, an applicant must pass a medical evaluation (discussed below) and a physical agility test. A successful applicant is assigned probationary status for 6 months and then becomes a regular member upon approval by the membership. The deceased fire fighter had been a volunteer fire fighter since 1996. He completed Fire Fighter 1 training but had not yet taken his certification test. Likewise, he had driver/operator training but was not certified. He also had first aid, CPR, and search and rescue training.

Preplacement Evaluations. The Department requires a preplacement medical evaluation for all applicants. This is done prior to the physical agility test. The evaluation is performed by a contract occupational medicine clinic, which has been instructed by the Fire Chief to follow the guidelines of the National Fire Protection Association (NFPA) 1582, *Standard on Medical Requirements for Fire Fighters and Information for Fire Department Physicians*.² The clinic makes a determination regarding medical clearance for fire fighting duties and forwards this decision to the Fire Department.

Periodic Evaluations. Within the past year, the Fire Department has instituted a limited annual medical evaluation. It is done by the same clinic that provides the preplacement evaluations and is intended to provide information upon which to base a decision on medical clearance for respirator use and to screen for other health problems. The evaluation consists of a self-administered medical and occupational history questionnaire, pulmonary function testing (PFT), and whatever additional testing the reviewing physician thinks is necessary. The Department can accommodate a fire fighter who is unable to wear a respirator or is otherwise unable to perform all fire fighting tasks. (Fire fighters who are members of the

regional hazardous materials (HAZMAT) team have an annual medical evaluation provided by that organization.) A volunteer who is injured or becomes ill, whether work-related or not, must be cleared to return to work as a fire fighter by a personal physician. The fire station does not have exercise equipment, but volunteers can use a local health club at a reduced rate. The Department's training program includes a session on preventive health, but the Department does not have a mandatory exercise/fitness program or other health promotion programs.

DISCUSSION

In the United States, coronary artery disease (atherosclerosis) is the most common risk factor for cardiac arrest and sudden cardiac death.³ Risk factors for its development include increasing age, male gender, heredity, tobacco smoke, high blood cholesterol, high blood pressure, physical inactivity, obesity and overweight, and diabetes.⁴ The deceased fire fighter had all of these risk factors except advanced age and diabetes.

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. Although the deceased fire fighter's autopsy identified 80% narrowing of the right coronary artery, no thrombus was identified in that artery. A thrombus was identified in a small artery, however.

Blood clots, or thrombus formation, in coronary arteries is initiated by disruption of atherosclerotic plaques. Certain characteristics of the plaques (size, composition of the cap and core, presence of a local



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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.^{8,9} Sudden cardiac death is often the first overt manifestation of ischemic heart disease.¹⁰

Fire fighting is widely acknowledged to be one of the most physically demanding and hazardous of all civilian occupations.¹¹ 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.¹²⁻¹⁴ Epidemiologic studies have found that heavy physical exertion sometimes immediately precedes and triggers the onset of acute heart attacks.¹⁵⁻¹⁹ The deceased fire fighter, wearing turnout gear, drove the engine, helped stretch hose, operated the pump, and helped return the engines to service (refill and clean them and stow equipment). Some of these tasks would involve moderate exertion, requiring 5 to 6 metabolic equivalents (MET).^{16, 20-22}

The Fire Department requires a preplacement medical evaluation for all applicants and recently instituted a limited annual evaluation. The content of the preplacement evaluation is supposed to comply with NFPA 1582.² NFPA 1582 recommends a brief medical evaluation annually and a more extensive evaluation periodically according to the age of the fire fighter (less than 30: every 3 years; 30-39: every 2 years; over 40 years: every year). NFPA 1582 recommends EST for fire fighters over the age of 35 with risk factors for CAD and for all fire fighters over age 40. The Department's annual evaluation does not include the limited physical examination (height, weight, blood pressure, heart rate and rhythm) that NFPA 1582 recommends, nor does the

Department routinely provide the more extensive periodic evaluations (as described above).

EST can be used to screen individuals for obstructive CAD. Unfortunately, it has problems with both false negatives (inadequate sensitivity) and false positives (inadequate specificity), particularly for asymptomatic individuals (individuals without symptoms suggestive of CAD), particularly in young men, and women.²³ ²⁴ Despite these problems, NFPA 1582 nevertheless recommends EST for fire fighters without risk factors for CAD beginning at age 40.² Other expert groups do **not** recommend EST for asymptomatic individuals without risk factors for CAD.²⁵⁻²⁷

When these asymptomatic individuals **have** risk factors for CAD, recommendations vary by organization. NFPA 1582 recommends biannual EST for fire fighters with CAD risk factors beginning at age 35.² For medical certification for the commercial drivers license (CDL) issued by the U. S. Department of Transportation (DOT), DOT recommends EST for drivers over the age of 45 with more than two CAD risk factors.²⁵ Since the deceased fire fighter was qualified as a driver/operator for the Fire Department, this regulation would seem to have relevance, but municipal fire departments are exempt from the DOT regulations.²⁸ In addition, the DOT medical advisory criteria are just that, advisory.

The American College of Cardiology/American Heart Association (ACC/AHA) do not think that "there is evidence and/or general agreement that [EST] is useful and effective" in asymptomatic persons without known CAD, but they identify four groups of such persons for which "there is conflicting evidence and/or a divergence of opinion about the usefulness/efficacy" of EST. In these groups, EST's "usefulness/efficacy is less well established by evidence/opinion" (as opposed to the "weight of evidence/opinion [being] in favor of usefulness/efficacy").²⁶



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- Group 1: Persons with multiple risk factors. Five risk factors for CAD are defined: hypercholesterolemia (total cholesterol greater than 240 mg/dL), hypertension (systolic blood pressure greater than 140 mm Hg or diastolic pressure greater than 90 mm Hg), smoking, diabetes, and family history of premature CAD (heart attack or sudden cardiac death in a first-degree relative less than 60 years old).
- Group 2: Men over the age of 40 and women over the age of 50 (especially if sedentary) who plan to start vigorous exercise.
- Group 3: Men over the age of 40 and women over the age of 50 who are at high risk for CAD due to other diseases (e.g., chronic renal failure).
- Group 4: Men over the age of 40 and women over the age of 50 who are involved in occupations in which impairment might impact public safety.

The deceased fire fighter met the criteria for Groups 1 and 4.

Finally, the U.S. Preventive Services Task Force (USPSTF) does not recommend EST for asymptomatic individuals, even those with risk factors for CAD; rather, they recommend the diagnosis and treatment of modifiable risk factors (hypertension, high cholesterol, smoking, and diabetes).²⁷ The USPSTF indicates that there is insufficient evidence to recommend screening middle age and older men or women in the general population but notes that “screening individuals in certain occupations (pilots, truck drivers, etc.) can be recommended on other grounds, including the possible benefits to public safety.”²⁷

Although the deceased fire fighter’s blood pressure and blood cholesterol were controlled by medication,

he smoked, did not engage in aerobic exercise on a regular basis, and was substantially overweight. Obesity, however, is not listed by NFPA 1582 as either a Category A (disqualifying) or B (possibly disqualifying, depending on degree or severity) medical condition.² It is possible that a health promotion program that included more vigorous exercise and weight control might have helped prevent his fatal heart attack. It is also possible that the annual medical evaluation (had it been in place before his death) would have resulted in additional medical testing, but whether a more recent ECG or an EST would have identified CAD, and whether he would have been medically cleared for fire fighting, with or without restrictions/accommodations, are open questions.

RECOMMENDATIONS AND DISCUSSION

The following recommendations address health and safety issues identified during this investigation. This list includes some preventive measures that have been recommended by other agencies to reduce the risk of on-the-job cardiac arrest among fire fighters. These selected recommendations have not been evaluated by NIOSH, but represent published research or consensus votes of Technical Committees of the National Fire Protection Association or fire service labor/management groups.

Recommendation #1: Expand the periodic medical evaluation program to conform to the recommendations of the National Fire Protection Association (NFPA) Standard 1582, Standard on Medical Requirements for Fire Fighters and Information for Fire Department Physicians, This program should incorporate EST, depending on the fire fighter’s age and CAD risk factors.

The purpose of periodic medical evaluations is to ensure that fire fighters have the ability to perform



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duties without presenting a significant risk to the safety and health of themselves or others. Guidance regarding the content and scheduling of periodic medical examinations for fire fighters can be found in NFPA 1582.² 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. NFPA 1582 recommends a limited annual evaluation, including a medical and occupational history, which the Department has instituted, and a limited physical examination (height, weight, blood pressure, heart rate and rhythm), which should be added. In addition, NFPA 1582 recommends a more extensive medical evaluation at an interval of 1 to 3 years, depending on the fire fighter's age. NFPA 1582 recommends that periodic EST begin at age 35 for those with CAD risk factors and at age 40 for those without CAD risk factors.

Applying NFPA 1582 involves legal and economic 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. The 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 8-7.2.²⁹ 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. Unfortunately, the second and third requirements may not be workable in a volunteer department and could

thus impair both acceptance by fire fighters and the Fire Department's ability to retain fire fighters.

Applying this recommendation involves economic repercussions and may be particularly difficult for small, rural, volunteer Fire Departments to implement. Ideally, the periodic evaluations would be provided by the occupational medicine clinic that provides the preplacement evaluations. Certainly, this could easily apply to the addition of the limited annual physical examination. The more extensive periodic evaluations could be performed by a personal physician or the contract occupational medicine clinic at the fire fighter's expense, provided by a physician volunteer, or paid for by the Fire Department. In any case, the medical clearance decision should be made by a physician knowledgeable about the physical demands of fire fighting and the personal protective equipment used by fire fighters. (Presumably, the contract occupational medicine clinic could provide this service.) Sharing the financial responsibility for these evaluations between volunteers, the Fire Department, and willing physician volunteers should reduce the negative financial impact on recruiting and retaining needed volunteers.

The medical evaluation for respirator use should involve considerations beyond respiratory symptoms and pulmonary function testing (PFT).³⁰⁻³² Although pulmonary status needs to be considered, cardiac health is a more important factor in determining whether a fire fighter is medically fit to use SCBA with turnout gear. The primary physiological burdens are the added weight of the air bottle and other turnout gear and the heat load resulting from the fire, exertion, and turnout clothing. Thus, the medical evaluation for respirator clearance depends more on the medical history and physical examination than on PFT. PFT may be useful for evaluating respiratory symptoms or physical examination findings, but it is otherwise not needed routinely for a respirator clearance evaluation. Many workers, however,



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including fire fighters, have periodic PFT for other reasons, and the results should obviously not be ignored. NFPA 1582 does not require PFT as part of the limited annual medical evaluation.²

Recommendation #2: The medical decision regarding an ill or injured fire fighter returning to duty should be made by the physician providing occupational health services for the Fire Department.

The decision regarding medical clearance for fire fighters requires knowledge not only of the fire fighter's medical condition, but also of the fire fighter's job duties and NFPA 1582 medical fitness criteria. NFPA 1582 recommends that return-to-duty evaluations be done by the "fire department physician"² (in this case, the contract occupational medicine clinic). As part of the return-to-duty evaluation, the fire department physician should review relevant records from the fire fighter's personal physicians and/or discuss with them the fire fighter's illness or injury.

Recommendation #3: Phase in a mandatory wellness/fitness program for fire fighters to reduce risk factors for cardiovascular disease and improve cardiovascular capacity.

NFPA 1500, *Standard on Fire Department Occupational Safety and Health Program*, requires a wellness program that provides health promotion activities for preventing health problems and enhancing overall well-being.²⁹ The International Association of Fire Fighters (IAFF) and the International Association of Fire Chiefs (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.³³ The Wellness/Fitness Initiative provides guidance regarding wellness program content, to include physical examination and evaluation, fitness, and behavioral health. Wellness programs have been shown to be cost effective, typically by reducing the number of work-related injuries and lost work days.^{34,35} An unpublished analysis by the Phoenix, Arizona, city auditor found a reduction in disability pension costs following a 12-year commitment to the wellness program at the Fire Department.

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INVESTIGATOR INFORMATION

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