F2002
03

NIOSH
Fire Fighter Fatality Investigation and Prevention Program

Death in the line of duty...

A Summary of a NIOSH fire fighter fatality investigation *September 9, 2002*

Fire Fighter Suffers Cardiac Arrest While Responding to a Structure Fire - Texas

SUMMARY

On December 24, 2001, a 43-year-old male volunteer Fire Fighter responded to a mutual-aid call for a fire in a single-family dwelling. After leaving the fire station in a Fire Department vehicle (Battalion 61) at 1020 hours heading south, he drove approximately 2 miles and collapsed onto the seat. The vehicle traveled through the median, entered the northbound lanes, and crossed a bridge before crashing into cedar trees and a stone wall. A bystander saw the accident and went to assist the victim. He found the victim unresponsive with no pulse and no respirations. Cardiopulmonary resuscitation (CPR) was begun immediately and an ambulance was requested. Approximately 89 minutes later, despite CPR and advanced life support (ALS) administered on the scene and at the hospital, the victim died. The death certificate and the autopsy, conducted by the Medical Examiner, listed "arteriosclerotic cardiovascular disease" as the immediate cause of death.

The following recommendations address some general health and safety issues. 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 they represent published research or consensus votes of technical committees of the National Fire Protection Association (NFPA) or fire service labor/management groups.

- ***Conduct <u>mandatory</u> preplacement medical evaluations consistent with NFPA 1582 to determine a candidate's medical ability to perform duties without presenting a significant risk to the safety and health of themselves or others.***
- ***Provide <u>mandatory</u> annual medical evaluations to <u>ALL</u> fire fighters to determine their medical ability to perform duties without presenting a significant risk to the safety and health of themselves or others. Exercise stress tests should be incorporated into these periodic medical evaluations.***
- ***Ensure that fire fighters are cleared for duty by a physician knowledgeable about the physical demands of fire fighting and the various components of NFPA 1582.***
- ***Provide fire fighters with medical evaluations and clearance to wear SCBA.***
- ***Phase in a mandatory wellness/fitness program for fire fighters to reduce risk factors for cardiovascular disease and improve cardiovascular capacity.***

Fire Fighter Suffers Cardiac Arrest While Responding to a Structure Fire - Texas

INTRODUCTION & METHODS

On December 24, 2001, a 43-year-old male Fire Fighter lost consciousness while responding to a structure fire. Despite CPR and ALS administered by a bystander, crew members, the ambulance crew, and in the emergency department, the victim died. On January 24, 2002, NIOSH contacted the affected Fire Department to initiate the investigation. On February 5, 2002, a Safety and Occupational Health Specialist from the NIOSH Fire Fighter Fatality Investigation Team traveled to Texas to conduct an on-site investigation of the incident.

During the investigation NIOSH personnel interviewed the following:

- Fire Chief
- Crew members on duty with the victim
- Ambulance paramedics
- Victim's wife

During the site-visit NIOSH personnel reviewed the following:

- Fire Department policies and operating guidelines
- Fire Department training records
- Fire Department annual report for 2001
- Fire Department incident report
- Emergency medical service (ambulance) incident report
- Hospital emergency department report
- Death certificate
- Autopsy report
- Past medical records of the deceased

INVESTIGATIVE RESULTS

Incident. On December 24, 2001, at 0958 hours, the involved Fire Department was dispatched on a mutual-aid call to assist a neighboring fire department at a structure fire involving a single-family mobile home. Engine 63 (Fire Chief and two Fire Fighters) and Tanker 61 (three Fire Fighters) responded. The victim responded to the fire station in his privately owned vehicle (POV) to drive any other necessary fire apparatus to the scene. At approximately 1020 hours, the victim responded in Battalion 61, a 1995 Dodge Ram pickup truck with box compartments along each side. Tanker 62 (two Fire Fighters) responded last.

Approximately 2 miles south from the fire station, the roadway changed from two lanes to four lanes with a grass median dividing northbound from southbound. The speed limit for this area was 65 miles per hour.

Heading southbound, the victim drove at an undetermined speed approximately 2 miles before collapsing onto the seat. Without the brakes being applied, Battalion 61 entered the median, striking a one-way sign and a stop sign at a crossover. Battalion 61 continued through the median for approximately 0.3 miles and entered the northbound lanes for approximately 0.7 miles, crossing a bridge (Photograph 1) before crashing into cedar trees and a stone wall 25 feet off the roadway (Photograph 2).

The accident caused major damage to the vehicle (photograph 3) including the steering wheel, windshield (large perforation in the center), and the exterior. The vehicle air bag deployed during the crash.

Seeing the accident, a bystander went to assist the victim. He found the victim lying across the seat, unresponsive, not breathing, and pulseless. Another bystander called 911. At 1022 hours, 911 dispatched an ambulance and at 1023 hours, 911 notified the involved Fire Department of the accident. The first bystander began CPR (chest compressions and assisted ventilations via mouth-to-mouth) immediately.

Tanker 62, en route to the previous call, arrived first at the motor-vehicle incident (MVI). Ambulance 1786 (three paramedics), Engine 61 (one Fire Fighter), and five additional fire fighters (in their POVs) also responded to the MVI. Engine 61 arrived on the scene at 1026 hours and requested mutual aid. 911 dispatched mutual-aid Engine 50 (Fire Chief, Fire Fighter-Paramedic, and Safety Officer) and EMS 53 (Fire Fighter and Fire Fighter-Paramedic) from a neighboring Fire Department.

Ambulance 1786 arrived on the scene at 1028 hours and found the victim lying on the passenger (right) side floorboard with his legs and feet trapped under the dashboard of the driver's (left) side. He was unresponsive, not breathing, and pulseless. Assisted ventilations via bag-valve-mask (BVM) with 100% oxygen were given while CPR continued. Neck and spinal immobilization was performed, the victim was placed onto a backboard, extricated, and placed into the ambulance. A cardiac monitor was applied, revealing asystole (no heartbeat). ALS measures including two IVs and intravenous therapy were begun. Two intubation attempts were unsuccessful due to excessive bleeding in the airway. The cardiac monitor revealed ventricular fibrillation, and a cardiac shock was immediately administered. The victim's heart rhythm reverted to asystole (no heartbeat) and CPR was continued. The airway was suctioned and the victim was ventilated for approximately 1 minute. Two additional attempts at intubation, including application of cricoid pressure to stop the bleeding, were unsuccessful. The victim was ventilated for approximately another minute. An AirLife rescue helicopter was put on standby at 1034 hours, requested and dispatched at 1038 hours, and launched at 1043 hours.

Engine 50 and EMS 53 arrived on the scene at 1053 hours. Two additional attempts at intubation by the EMS 53 Paramedic were also unsuccessful. CPR remained in progress. AirLife arrived on the scene at 1058 hours and found the victim unresponsive, not breathing, and pulseless with CPR in progress. The victim was then loaded onto a stretcher and placed into the helicopter, which began transport to the hospital at 1125 hours. A cardiac monitor from AirLife was attached to the victim and still revealed asystole. ALS measures, including a successful intubation and chest decompression, were initiated. Throughout the flight there was no change in patient status. The victim arrived at the hospital emergency department at 1137 hours. Inside the emergency department CPR and ALS measures continued until 1151 hours, when the victim was pronounced dead by the attending physician.

Medical Findings. The death certificate was completed by the Medical Examiner, who listed "arteriosclerotic cardiovascular disease" as the immediate cause of death. Pertinent findings from the autopsy, also performed by the Medical Examiner, on December 25, 2001, included

- Atherosclerosis of the coronary arteries
  - 98% narrowing of the mid-right coronary artery
  - 90% narrowing of the proximal left anterior descending coronary artery
  - 50% narrowing of the circumflex artery
- Cardiomegaly (enlarged heart weighing 600 grams)
- Old posterolateral myocardial infarction (prior heart attack)
- Bilateral ventricular dilatation

Nonlethal traumatic injuries included
- Fractures of left 4-6 ribs
- Abrasions and cuts of face

The drug screen was negative for alcohol, illicit drug use, and carbon monoxide.

Fire Fighter Suffers Cardiac Arrest While Responding to a Structure Fire - Texas

The Fire Fighter had the following risk factors for coronary artery disease (CAD): male gender, smoking, hypertension, hypercholesterolemia, and obesity. The victim was currently prescribed high blood pressure and cholesterol-lowering medications. In November 2000 the victim saw a physician for a routine visit. The exam revealed a height of 6 feet, a weight of 246 pounds, and a blood pressure of 122/80. He was not under any restrictions for fire-fighting duties.

According to his wife and crew members, the Fire Fighter did not express symptoms of chest pain or any other symptom indicative of a heart attack at any time preceding the incident. He pinched his left ulnar nerve in a work-related incident in May 2001 and suffered radiating pain from his left shoulder to his fingertips. The day of the incident, the victim had just risen from bed and gotten dressed when the mutual-aid call was received.

DESCRIPTION OF THE FIRE DEPARTMENT

At the time of the NIOSH investigation, the combination Fire Department consisted of 2 full-time, 4 part-time, and 50 volunteer fire fighters and served a population of 5,000 in a geographic area of 200 square miles. There are two fire stations.

In 2001, the Department responded to 529 calls: 272 emergency medical calls, 53 dispatched and canceled en route calls, 37 motor-vehicle accidents, 31 wildland fires, 24 authorized/unauthorized burning calls, 23 structure fires, 18 standby/move-up calls, 17 search/rescue calls, 16 false calls (good intent/mistaken citizen/malicious/bomb scare/system malfunction), 10 public assist (distress/lock out/other) calls, 9 vehicle fires, 7 rubbish/trash/dumpster fires, 4 hazardous materials (spills/leaks), 3 other fires, 3 other (cleanup/remove hazard) calls, and 2 other calls.

Training. New career fire fighter applicants must possess a State Class B driver's license and pass a written test, a skills test, and an oral interview before being hired. Once hired, fire fighters must become State-certified fire fighters and EMT-Basic within 1 year.

New volunteer fire fighter applicants must be over age 18, possess a State Class B driver's license, be certified as an EMT-Basic, pass an oral interview, and be voted on by the membership. Once selected, the fire fighter must attend training and emergency responses and pass a background check. The volunteer fire fighter receives training on the essentials of fire fighting in-house or is sent to State Fire Academy. State certification is voluntary; however, the fire fighter must be trained to the Fire Fighter 1 level before fighting structure fires. Fire fighters receive recurrent training in their station at weekly drills. The State requirement for minimum volunteer fire fighter certification is 167 hours for Basic Fire Fighter, an additional 193 hours for Intermediate Fire Fighter, and an additional 187 hours for Advanced Fire Fighter. State Fire Academy consists of 580 hours and trains fire fighters to the Fire Fighter-Basic/EMT-Basic level.

All fire fighter applicants who wish to be State-certified must pass a written State test.

The State requirement for annual State-certified fire fighter recertification is 20 hours. Annual recertification is also required for hazardous materials certification. First Responders, EMTs and Paramedics recertify every 2 years. The victim was trained as a Fire Fighter and a Driver/Operator, and he had 9 years of fire-fighting experience.

Preplacement Evaluations. The Fire Department does not require a preplacement medical evaluation for new members. A timed performance evaluation

of typical fire-fighting duties (physical ability test) is required for career members.

Periodic Evaluations. No annual medical evaluations or physical ability tests are required by the Department. However, annual 12-lead EKGs are performed by the ambulance service, semi-annual blood pressure checks are performed by the Fire Department, and an allergic reactions and medications list is being initiated by the Fire Department. Fire fighters are encouraged to receive a complete physical examination through their employer or at their own expense.

Medical clearance for SCBA use is not required. If a fire fighter is injured on duty or is ill and misses work, he/she must be cleared for return to work by his/her personal physician.

Strength equipment is available at the fire station but not aerobic equipment. No wellness program is available.

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 age over 45, male gender, family history of coronary artery disease, smoking, high blood pressure, high blood cholesterol, obesity, physical inactivity, and diabetes.[2,3] The victim had five of these risk factors (male gender, smoking, high blood pressure, high blood cholesterol, and obesity), and his autopsy revealed an "old" MI. By all accounts, the victim never reported symptoms of angina, of congestive heart failure (shortness of breath, dyspnea on exertion, swollen ankles, etc.). Unfortunately, sudden cardiac death is the presenting condition in up to 20% of cases of coronary artery disease (CAD).

The narrowing of the coronary arteries by atherosclerotic plaques occurs over many years, typically decades.[4] However, the growth of these plaques probably occurs in a nonlinear, often abrupt fashion.[5] 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.[6] This sudden blockage is primarily due to blood clots (thrombosis) forming on the top of atherosclerotic plaques. No thrombus was present at autopsy, although the lack of a thrombus doesn't rule out a heart attack. His clinical scenario is most consistent with an MI-induced arrhythmia leading to sudden cardiac death.

Blood clots, or thrombus formation, in coronary arteries are initiated by disruption of atherosclerotic plaques. Certain characteristics of the plaques (size, composition of the cap and core, presence of a local inflammatory process) predispose the plaque to disruption.[6] 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.[7,8]

Fire fighting is widely acknowledged to be one of the most physically demanding and hazardous of all civilian occupations.[9] 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.[10-12] Prior to his collapse and the accident, the victim had responded in his POV from his home to the fire station and began driving Battalion 61 to the call. This is considered a light level of physical exertion.[13]

The victim's autopsy also revealed both ventricles were dilated. Dilated cardiomyopathy is a condition characterized by dilatation of the heart chambers and

impaired ventricular contraction (pumping). In this individual, this dilatation was most likely due to his underlying CAD.

To reduce the risk of heart attacks and sudden cardiac arrest among fire fighters, the NFPA has developed the NFPA 1582 guideline entitled *S tandard on Medical Requirements for Fire Fighters and Information for Fire Department Physicians*.[14] NFPA 1582 recommends a yearly physical evaluation to include a medical history, height, weight, blood pressure, and visual acuity test.[14] NFPA 1582 recommends a thorough examination to include vision testing, audiometry, pulmonary function testing, a complete blood count, urinalysis, and biochemical (blood) test battery be conducted on a periodic basis according to the age of the fire fighter (less than 30: every 3 years; 30-39: every 2 years; over 40 years: every year). The Fire Department does not currently offer preemployment/ preplacement or periodic physical evaluations to fire fighters.

NFPA 1582 also recommends fire fighters over the age of 35 with risk factors for CAD be screened for obstructive CAD by an EST.[14] Unfortunately, the EST has problems with both false negatives (inadequate sensitivity) and false positives (inadequate specificity), particularly for asymptomatic individuals (individuals without symptoms suggestive of angina), young men, and women.[15,16] This has led other expert groups to **not** recommend EST for asymptomatic individuals without risk factors for CAD.[17,18]

When these asymptomatic individuals **have** risk factors for CAD, however, recommendations vary by organization. The American College of Cardiology/American Heart Association (ACC/ AHA) identifies two groups for EST: (1) men over the age of 40 with a history of cardiac disease (as a screening test before beginning a strenuous exercise program), and (2) men over age 40 with one or more risk factors.[17] They define five risk factors for CAD: hypercholesterolemia (total cholesterol greater than 240 mg/dL), hypertension (systolic greater than 140 mm Hg or diastolic greater than 90 mm Hg), smoking, diabetes, and family history of premature CAD (cardiac event in first-degree relative less than 60 years old).[16] 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).[18]

These recommendations change for individuals who might endanger public safety if an acute episode were experienced or those who require high cardiovascular performance such as police and fire fighters. The NFPA recommends fire fighters without CAD risk factors get their first EST at age 40; for those with one or more CAD risk factors, at age 35.[14] NFPA considers CAD risk factors to be family history of premature (less than age 55) cardiac event, hypertension, diabetes mellitus, cigarette smoking, and hypercholesterolemia (total cholesterol greater than 240 mg/dL or HDL cholesterol less than 35 mg/dL).[14] The EST should then be performed on a periodic basis, at least once every 2 years.[14] The ACC/AHA indicates that the data are insufficient to justify periodic EST in people involved in public safety; however, as mentioned previously, they recommend that men over age 40 with a history of cardiac disease be screened before beginning a strenuous exercise program.[17] Fire suppression activities involve strenuous physical activity; therefore, the ACC/AHA seem to be making a distinction between those already engaged in strenuous physical activity (conditioning), and those **beginning** a strenuous exercise program. The USPSTF indicates that the evidence is insufficient 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."[18]

Since the victim had risk factors for CAD and was over 35 years of age, an EST would have been recommended by NFPA 1582. However, the AHA and the USPSTF are less clear about whether an EST should have been performed in this individual. It is possible an EST may have identified the victim's CAD and led to medical treatment.

RECOMMENDATIONS

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 they represent published research or consensus votes of technical committees of the NFPA or fire service labor/management groups.

Recommendation #1: Conduct mandatory preplacement medical evaluations consistent with NFPA 1582 to determine a candidate's 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 preplacement medical evaluations and examinations for fire fighters can be found in NFPA 1582, *Standard on Medical Requirements for Fire Fighters and Information for Fire Department Physicians*,[14] and in the report of the International Association of Fire Fighters/International Association of Fire Chiefs (IAFF/IAFC) wellness/fitness initiative.[19] The Fire Department is not legally required to follow any of these standards. Nonetheless, we recommend the County and the Fire Department be consistent with the above guidelines.

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 should be applied 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.[20]

The success of medical programs hinges on protecting the affected fire fighter. The Fire 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.

Recommendation #2: Provide mandatory annual medical evaluations to ALL fire fighters 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[14] and in the IAFF/IAFC wellness/fitness initiative.[19] The Fire Department is not legally required to follow any of these standards. Nonetheless, we recommend the County establish the content and frequency to be consistent with the above guidelines. NFPA 1582

and the IAFF/IAFC wellness/fitness initiative both recommend at least biannual EST for fire fighters.[14,19] They recommend that these tests begin at age 35 for those with CAD risk factors and at age 40 for those without CAD risk factors. The EST could be conducted by the fire fighter's personal physician or a City/County contract physician. If the fire fighter's personal physician conducts the test, the results must be communicated to the contract physician, who should be responsible for decisions regarding medical clearance for fire-fighting duties.

Applying this recommendation involves economic repercussions and may be particularly difficult for small, rural, volunteer fire departments to implement. Certainly, this could easily apply to the addition of a 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.

Recommendation #3: Ensure that fire fighters are cleared for duty by a physician knowledgeable about the physical demands of fire fighting and the various components of NFPA 1582.

Physicians providing input regarding medical clearance for fire-fighting duties should be knowledgeable about the physical demands of fire fighting and familiar with the consensus guidelines published by NFPA 1582. To ensure physicians are aware of these guidelines, we recommend that the Fire Department provide the contract and private physicians with a copy of NFPA 1582. In addition, we recommend the Fire Department not automatically accept the opinion of the employee's private physician regarding return to work. This decision requires knowledge not only of the employee's medical condition but also of the employee's job duties. Frequently, private physicians are not familiar with an employee's job duties or with guidance documents such as NFPA 1582. Lastly, we recommend that all return-to-work clearances be reviewed by a County/Fire Department contracted physician. Thus, the final decision regarding medical clearance for return to work lies with the County/Fire Department with input from many sources including the employees private physician.

Recommendation #4: Provide fire fighters with medical evaluations and clearance to wear SCBA.

OSHA's Revised Respiratory Protection Standard requires employers to provide medical evaluations and clearance for employees using respiratory protection.[21] These clearance evaluations are required for private industry employees and public employees in States operating OSHA-approved State plans. Texas is not a State-plan State; therefore, public sector employers are not required to comply with OSHA standards. Nonetheless, we recommend voluntary compliance with the Respiratory Protection Standard. A copy of the OSHA medical checklist has been provided to the Fire Department.

Recommendation #5: Phase in a mandatory wellness/fitness program for fire fighters to

reduce risk factors for cardiovascular disease and improve cardiovascular capacity.

Physical inactivity is the most prevalent modifiable risk factor for CAD in the United States. Additionally, physical inactivity, or lack of exercise, is associated with other risk factors, namely obesity and diabetes.[22] NFPA 1500, *Standard on Fire Department Occupational Safety and Health Program*, and NFPA 1583, *Standard on Health-Related Fitness Programs for Fire Fighters*, require a wellness program that provides health promotion activities for preventing health problems and enhancing overall well-being.[20,23] In 1997, the International Association of Fire Fighters (IAFF) and the International Association of Fire Chiefs (IAFC) published 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.[19] The Fire Department should review these materials to identify applicable elements. Other large-city negotiated programs can also be reviewed as potential models.

REFERENCES

1. Fauci AS, Braunwald E, Isselbacher KJ, et al. [1998]. Harrison's principles of internal medicine, 14th ed. New York: McGraw-Hill, pp. 222-225.

2. American Heart Association (AHA) [1998]. AHA scientific position, risk factors for coronary artery disease, Dallas, TX.

3. Jackson E, Skerrett PJ, Ridker PM [2001]. Epidemiology of arterial thrombosis. In: Coleman RW, Hirsh J, Marder VIJ, et al., eds. 4th ed. Homeostasis and thrombosis: basic principles and clinical practice. Philadelphia, PA: Lippincott Williams and Wilkins.

4. Fauci AS, Braunwald E, Isselbacher KJ, et al. [1998]. Harrison's principles of internal medicine. 14th ed. New York: McGraw-Hill, p. 1348.

5. Shah PK [1997]. Plaque disruption and coronary thrombosis: new insight into pathogenesis and prevention. Clin Cardiol *20* (11 Suppl2): II-38-44.

6. 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.

7. Kondo NI, Muller JE [1995]. Triggering of acute myocardial infarction. J Cardiovasc Risk *2*(6):499-504.

8. Opie LH [1995]. New concepts regarding events that lead to myocardial infarction. Cardiovasc Drug Ther *9* Suppl 3:479-487.

9. Gledhill N, Jamnik, VK [1992]. Characterization of the physical demands of firefighting. Can J Spt Sci *17*(3):207-213.

10. Barnard RJ, Duncan HW [1975]. Heart rate and ECG responses of fire fighters. J Occup Med *17*:247-250.

11. 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.

12. Lemon PW, Hermiston RT [1977]. The human energy cost of fire fighting. J Occup Med *19*:558-562.

13. American Industrial Hygiene Association Journal [1971]. Ergonomics guide to assessment of metabolic and cardiac costs of physical work. Am Ind Hyg Assoc J, pp. 560-564.

14. NFPA [2000]. NFPA 1582, Standard on medical requirements for fire fighters and information for fire department physicians. Quincy, MA: National Fire Protection Association.

15. Michaelides AP, Psomadaki ZD, Dilaveris PE [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. Darrow MD [1999]. Ordering and understanding the exercise stress test. American Family Physician. January 15, 1999.

17. Gibbons RJ, Balady GJ, Beasley JW, Bricker JT, Duvernoy WFC, Froelicher VF, Mark DB, Marwick TH, McCallister BD, Thompson PD, Winters WL Jr, Yanowitz FG [1997]. ACC/AHA guidelines for exercise testing: a report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines (Committee on Exercise Testing). J Am Coll Cardiol *30*:260-315.

18. U.S. Preventive Services Task Force [1996]. Guide to clinical prevention services. 2nd ed. Baltimore, MD: Williams & Wilkins, pp. 3-15.

19. IAFF, IAFC [2000]. The fire service joint labor management wellness/fitness initiative. Washington: International Association of Fire Fighters, International Association of Fire Chiefs.

20. NFPA [1997]. NFPA 1500, Standard on fire department occupational safety and health program. Quincy, MA: National Fire Protection Association.

21. 29 CFR 1910.134. Code of Federal Regulations. Occupational Safety and Health Administration: Respiratory Protection. Washington, DC: National Archives and Records Administration, Office of the Federal Register.

22. Plowman SA, Smith DL [1997]. Exercise physiology: for health, fitness and performance. Boston, MA: Allyn and Bacon.

23. NFPA [2000]. NFPA 1583, Standard on health-related fitness programs for fire fighters. Quincy, MA: National Fire Protection Association.

INVESTIGATOR INFORMATION

This investigation was conducted by and the report written by Tommy N. Baldwin, MS, Safety and Occupational Health Specialist. Mr. Baldwin is with the NIOSH Fire Fighter Fatality Investigation and Prevention Program, Cardiovascular Disease Component, located in Cincinnati, Ohio.

Photo 1. The Divided Highway and the Bridge

Fire Fighter Suffers Cardiac Arrest While Responding to a Structure Fire - Texas

Photo 2. The Impact Area Including the Stone Wall and the Trees

Photo 3. The Vehicle Damage