



Fire Fighter Suffers Probable Heart Attack at Condominium Fire - South Carolina

SUMMARY

On January 21, 2002, a 48-year-old male career Assistant Chief responded to a structure fire involving a two-story condominium. The victim drove an engine to the fire scene and directed interior fire operations before collapsing. Seeing him fall, crew members came to his assistance and found him unresponsive, with no pulse and no respirations. Cardiopulmonary resuscitation (CPR) was begun immediately, and an ambulance arrived on-scene eleven minutes later. Approximately one hour later, despite CPR and advanced life support (ALS) administered on-scene and at the hospital, the victim died. The death certificate completed by the County Coroner and the autopsy conducted by the County pathologist both listed "arteriosclerotic cardiovascular disease" as the cause of death. Approximately two months prior to his death, as part of the Fire Department's annual medical evaluation, the victim had a cycle ergometer test with revealed ischemic changes (significant coronary artery disease). He was not cleared for fire fighting duties by the contract physician, however this information did not come to the attention of the Fire Department Chief or City Officials until after his 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.

- *Designate a City employee to administer the FD pre-placement and annual medical evaluations and their outcomes.*
- *Provide staff for FD clerical/administrative duties.*
- *Provide mandatory pre-placement and annual medical evaluations for ALL fire fighters, not just career personnel, to determine a fire fighter's medical ability to perform duties without presenting a significant risk to the safety and health of themselves or others.*
- *Fire Fighters should be cleared for duty by a physician knowledgeable about the physical demands of fire fighting and the various components of NFPA 1582.*
- *Follow provisions in OSHA's Respiratory Protection Standard and staff fire stations to ensure adequate emergency response capability for the community and safety of personnel.*

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



Fatality Assessment and Control Evaluation Investigative Report #F2002-30

Fire Fighter Suffers Probable Heart Attack at Condominium Fire - South Carolina

- *Phase-in a mandatory wellness/fitness program for fire fighters to reduce risk factors for cardiovascular disease and improve cardiovascular capacity.*

INTRODUCTION & METHODS

On January 21, 2002, a 48-year-old male fire fighter lost consciousness after directing interior operations at a condominium fire. Despite CPR and ALS administered by crew members, the ambulance crew, and in the emergency department, the victim died. On March 1, 2002, NIOSH contacted the affected Fire Department (FD) to initiate the investigation. On August 14, 2002, a Safety and Occupational Health Specialist, an Occupational Nurse Practitioner, and an Occupational Medicine Physician from the NIOSH Fire Fighter Fatality Investigation Team traveled to South Carolina to conduct an on-site investigation of the incident.

During the investigation NIOSH personnel interviewed the

- Fire Chief
- Crew members
- Victim's parent
- Director of Public Safety
- Town Administrator

During the site visit NIOSH personnel reviewed

- FD incident reports
- Police Department incident reports
- The victim's training records
- Death certificate
- Autopsy report
- Past medical records of the deceased
- Arson Investigation report
- Dispatch records
- Fire fighter statements
- Photographs of the fire scene
- Visited the fire scene.

INVESTIGATIVE RESULTS

Incident. On January 21, 2002, at 1613 hours, the involved Fire Department was dispatched to a possible house fire. Engine 1 (one fire fighter), Engine 2 (one fire fighter), Engine 3 (the victim), Ladder 4 (one fire fighter), and Car 1 (Fire Chief) responded and arrived on the scene at 1616 hours. Fifteen additional volunteer fire fighters responded directly to the fire scene in their privately owned vehicles (POVs). Engine 1 was the pumping engine and Engine 2 was the relay engine (hydrant).

The involved structure was a two-story, wood frame single-family dwelling constructed on stilts (equating to a three story structure). A exterior stairway led from the ground to the first floor and an interior stairway led from the first floor to the second floor. Light smoke was emitting from the eaves. The Fire Chief assumed incident command and first entered the structure to continue sizeup and to determine the extent of fire spread. There was very light smoke on the first floor; the second floor had very heavy smoke and visible fire. The Chief exited the structure, radioed Dispatch, and advised the fire attack team regarding the location and extent of the fire.

The fire attack team (three fire fighters) climbed the exterior stairway (approximately ten feet high) wearing full bunker gear, a self-contained-breathing-apparatus (SCBA) with air "on," and a charged 1¾-inch hoseline. Once inside the structure, they climbed the interior stairway (approximately ten feet high) and began the initial fire attack. The fire attack progressed normally, and containment was accomplished in approximately 60 seconds.

A backup team (three fire fighters including the victim) advanced a second charged 1¾-inch hoseline onto the second floor. Two additional fire fighters remained outside the structure as a rapid response or rapid intervention team (RIT). The victim directed fire fighters inside to perform ventilation, check for fire



Fire Fighter Suffers Probable Heart Attack at Condominium Fire - South Carolina

extension, and begin overhaul. After completing ventilation, a fire fighter approached the victim to inform him of the completed task. At that point, the victim began coughing and grabbed the fire fighter's coat and collapsed, causing them both to tumbled onto the floor.

The fire fighter yelled for assistance, called the Incident Commander via portable radio, and pulled the victim down the steps to the first floor. Crew members assisted in removing the victim's helmet, SCBA, and coat. Initial assessment by crew members found the Assistant Chief to be unresponsive, not breathing, and pulseless. An automated external defibrillator (AED) and the medical jump kit was requested. CPR (chest compressions and assisted ventilations via mouth-to-mouth) began immediately. The Incident Commander notified dispatch at 1638 hours and an ambulance [one Paramedic and one Emergency Medical Technician (EMT)] was dispatched. The AED was attached to the victim, revealing a shockable rhythm and one shock was administered. Five additional analyses did not reveal a shockable rhythm and CPR was continued.

The ambulance arrived on the scene at 1641 hours. The EMT and Paramedic found the victim unresponsive, not breathing, and pulseless, with CPR in progress. A cardiac monitor was attached to the victim, revealing asystole (no heart beat) which is not a shockable heart rhythm. ALS measures, including intubation, assisted ventilations via bag-valve-mask, and intravenous therapy, were begun. Pt was intubated on second attempt and successful placement was verified using an esophageal detector device (aspiration bulb technique). One round of ALS medications were administered then the victim was loaded onto a stretcher and, with some difficulty, moved to the ambulance stretcher. The ambulance left the scene at 1646 hours and arrived at the hospital emergency department at approximately 1706 hours. CPR and ALS measures continued until 1731 hours,

when the victim was pronounced dead by the attending physician.

Medical Findings.

The autopsy, performed by the pathologist of the local hospital on January 22, 2002, listed "arteriosclerotic cardiovascular disease" as the cause of death. The carboxyhemoglobin (COHb) concentration (a measure of carbon monoxide exposure) in blood obtained at autopsy was at a medically insignificant level. His urine and blood drug screen was negative for illicit drugs and alcohol. Pertinent findings from the autopsy are listed below:

Arteriosclerotic cardiovascular disease:

- Ischemic fibrosis with scarring, consistent with an remote, healed heart attack (infarct)
- Coronary atherosclerosis
(90%) segmental occlusion of the left anterior descending coronary artery
- Aortic atherosclerosis with ulcerating plaques
- A large heart (500 grams with normal being less than 400 grams in adult males).

The Assistant Chief had the following risk factors for coronary artery disease (CAD): male gender, age over 45, hypertension, hypercholesterolemia, diabetes mellitus, physical inactivity, and obesity. He was taking oral medication for his diabetes and his high blood pressure. Except for home and yard work the assistant chief did not engage in regular strenuous physical activity. According to his family, friends, and co-workers, the victim had no history of heart problems and pain during the days or weeks prior to his fatal event. The deceased never had an exercise stress test (EST), a screening test used to identify patients at risk for a heart attack or sudden cardiac death.

In 1997 the deceased was not cleared for duty during the FD's annual medical evaluation due to an elevated blood pressure. He was subsequently treated and cleared for full duty two and a half months later. On



Fire Fighter Suffers Probable Heart Attack at Condominium Fire - South Carolina

November 15, 2001, he had his annual FD physical examination performed by the city's contracted clinic. The exam revealed obesity, hypercholesterolemia, hyperglycemia, hypertension and an aerobic capacity of 25.7 ml/kg/min using a cycle ergometer test (CET). The CET lasted six minutes during which time the deceased reached approximately 81% of his maximum heart rate. A 12 lead electrocardiogram (EKG) tracing was taken during the six minute exercise period and the five minute recovery period of the CET. The EKG tracing revealed ischemic changes. The victim was not cleared for fire fighting duties and referred to his primary care physician (PCP) for further evaluation and full-duty clearance. A copy of this evaluation, with a statement that the deceased would need to get duty clearance from his PCP, was sent to the FD. The results of these annual evaluations were typically handled by the Assistant Chief (the deceased) or the Fire Chief. Unfortunately, the victim never visited his PCP, was never cleared for fire fighting duties, and failed to bring this to the attention of the Fire Chief.

**DESCRIPTION OF THE FIRE
DEPARTMENT**

At the time of the NIOSH investigation, the combination Fire Department consisted of five career fire fighters and 25 volunteers and served a resident population of 4,500 (plus a non-resident population of 20,000) in a geographic area of 2.25 square miles. There is one fire station. Fire fighters work the following schedule: 24 hours on-duty, 48 hours off-duty, from 0800 hours to 0800 hours. The victim worked 0800 hours to 1700 hours, Monday through Friday and was on call the remainder of the time. In 2001, the Fire Department responded to 485 calls: 256 rescue calls, 102 other calls, 48 false alarms, 36 service calls, 29 fires, and 14 good intent calls.

Training. Career applicants must be certified in structural fire fighting. Once hired, the fire fighter receives training for engineer and fire marshal certification. Fire fighters receive recurrent training in their station on each shift and at weekly drills. Volunteer fire fighter candidates must complete an application. If selected, the candidate has a year to become certified as an interior structural fire fighter at their own expense. As a member of the FD, volunteers receive the same training as the career fire fighters. Other than for hazardous material certification, the FD is not required to re-certify their fire fighters. EMTs and Paramedics re-certify every three years. The victim was trained as a Interior Structural Fire Fighter, Engineer, Hazardous Materials operations level, Fire Inspector, and Fire Service Instructor and he had 22 years of fire-fighting experience.

Pre-placement Evaluations.

At the time of this incident, the FD required a pre-placement medical evaluation for career, but not volunteer, fire fighters. The components of this evaluation are listed below:

- A complete medical history
- Height, weight, and vital signs
- Physical examination
- Blood tests: Comprehensive metabolic panel, complete blood count with differential (CBC), lipid, and liver profile
- Urine tests: Urinalysis
- Spirometry
- Resting electrocardiogram (ECG) for those over 40 years of age
- Audiogram
- Vision test

These evaluations are performed by a local physician hired by the city. Once this evaluation is complete, a decision regarding medical clearance for fire fighting duties is made by the examining physician and forwarded to the FD.



Fire Fighter Suffers Probable Heart Attack at Condominium Fire - South Carolina

Periodic Evaluations.

At the time of this incident, the FD required annual medical evaluations for all career fire fighters, and non-mandatory annual evaluations for volunteer fire fighters. Currently, this annual medical evaluation is for all fire fighters, regardless of their career status. The components of this evaluation were the same as the pre-placement medical evaluation with the addition of a measure of aerobic capacity using a CET. These evaluations are performed by a medical clinic under contract with the City. Once this evaluation is complete, a decision regarding medical clearance for fire fighting duties is made by the examining physician and forwarded to the FD. The cardiovascular fitness testing consisted of a CET utilizing a 12 lead EKG to ascertain the pulse rate. If EKG changes are noted during the CET or other precluding medical conditions are identified during the evaluation, follow-up with the PCP is recommended before clearance can be given for fire suppression activities.

The department does not conduct physical agility tests for their pre-placement or periodic evaluation. However, the FD does, as mentioned earlier, conduct aerobic capacity tests on incumbents. The FD has a voluntary wellness program which includes nutrition and wellness information along with individualized fitness plans based on the results of the CET provided by the contractor. Participation in this fitness program is not mandatory. The fire station has strength and aerobic equipment available. The victim did not exercise frequently either at home or work.

Medical clearance for SCBA use is conducted yearly by the same clinic that performs the periodic evaluations. If an employee has either an occupational/non-occupational injury or illness involving time away from work, he/she must be cleared for "return to work" by their personal physician. The FD accommodates members who are unable to perform a full range of duties due to

health problems or age, by limiting their duty to tasks they can perform..

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 including increasing age, male gender, heredity, tobacco smoke, high blood cholesterol, high blood pressure, physical inactivity, obesity and overweight, and diabetes.² The deceased fire fighter had seven of these risk factors.

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. No thrombus was present at autopsy, however there was identified a 90% segmental occlusion of the left anterior descending coronary artery and aortic atherosclerosis.

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 inflammatory process) predispose the plaque to disruption.⁵ 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.^{6,7}

Firefighting is widely acknowledged to be one of the most physically demanding and hazardous of all



Fire Fighter Suffers Probable Heart Attack at Condominium Fire - South Carolina

civilian occupations.⁸ Firefighting 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.⁹⁻¹¹ Epidemiologic studies have found that heavy physical exertion sometimes immediately precedes and triggers the onset of acute heart attacks.¹²⁻¹⁶ Prior to his collapse, the deceased fire fighter was wearing turnout gear and SCBA weighing approximately 50 pounds. He then climbed two flights of stairs (approximately 20 feet) pulling a charged (filled with water) 1¾ inch hose. Once on the second floor, he conducted overhaul, ventilation and searching for additional fire. These activities constitute strenuous physical exertion.¹⁷⁻²⁰

Prior to this event, the victim had no symptoms of angina (heart muscle pain). Unfortunately, sudden cardiac death is often the first overt manifestations of ischemic heart disease.²¹ Although asymptomatic, the deceased did have an abnormal EKG changes while conducting a CET on November 29, 2001. These changes were interpreted as ischemic and were consistent with the coronary atherosclerosis identified on the autopsy. The microscopic findings of “areas of myocardial fibrosis and scarring consistent with a previous infarct” is also with a his CAD.

To reduce the risk of sudden cardiac arrest and heart attacks among fire fighters as well as other medical causes of incapacitation, NFPA has developed its “Standard on Medical Requirements for Fire Fighters and Information for Fire Department Physicians,” otherwise known as 1582.²² NFPA 1582 recommends that, as part of its appendix which is for “informational purposes only,” fire fighters over the age of 35 with risk factors for CAD be screened for obstructive CAD by an Exercise Stress Test (EST). In this case, the deceased had a CET performed to assess his aerobic capacity, not an diagnostic EST to screen for ischemic heart disease.

Nonetheless, the CET showed ischemic changes. It also showed an aerobic capacity of 25.7 ml/kg/min giving him a poor capacity for his age group (32-35ml/kg/min).²³ Minimal aerobic capacities recommended for fire fighters range from 38-45 ml/kg/min.²⁴⁻²⁸

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

Recommendation #1: Designate a City employee to administer the FD pre-placement and annual medical evaluations and their outcomes.

This employee should maintain the confidentiality of the medical records. If this employee is a member of the FD and participating in the City’s annual medical evaluation, a policy should prevent them from administering the resulting of the program to themselves.

Recommendation #2: Provide staff for FD clerical/administrative duties.

The shortage of clerical staff at the FD has resulted in relatively mundane tasks being completed by its professional staff, thereby underutilizing their extensive expertise. The services of the professional staff could be better used toward the fulfilling the critical programs offered by the FD.

Recommendation #3: Provide mandatory pre-placement and annual medical evaluations for ALL fire fighters, not just career personnel, to



Fire Fighter Suffers Probable Heart Attack at Condominium Fire - South Carolina

determine a fire fighter'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 periodic 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*²² and in the report of the International Association of Fire Fighters/International Association of Fire Chiefs (IAFF/IAFC) wellness/fitness initiative.²⁹ The Department is not legally required to follow any of these standards. Nonetheless, we recommend the City and the Fire Department be consistent with the above guidelines.

Recommendation #4: Fire Fighters should be 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 firefighting and familiar with the consensus guidelines published by NFPA 1582, Standard on Medical Requirements for Fire Fighters and Information for Fire Department Physicians. To ensure private physicians are aware of these guidelines, we recommend that the Fire Department provide the 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 the employee's job duties. Frequently, private physicians are not familiar with an employee's job duties, or guidance documents, such as NFPA 1582. Lastly, we recommend that all return-to-work clearances be reviewed by the Fire Department physician/

contracted physician. Thus, the final decision regarding medical clearance for return to work lies with the Fire Department with input from many sources including the employee's private physician.

Recommendation #5: Follow provisions in OSHA's Respiratory Protection Standard and staff fire stations to ensure adequate emergency response capability for the community and safety of personnel.

After this incident, South Carolina OSHA conducted an inspection of the affected FD. The inspection noted a few compliance deficiencies in their Respiratory Protection Standard (written program, annual respirator fit testing, medical clearance).³⁰ These deficiencies have been addressed by the FD. Another provision in OSHA's Respiratory Protection Standard, is having adequate staffing prior to entering structures with hazards immediately dangerous to life and health (so-called "two in: two out"). Although staffing levels were unrelated to the victim's collapse, it represents a potential safety problem. Voluntary NFPA standards (1500 and 1710)^{31,32} also emphasize the need for adequate staffing to safely engage in fire suppression and emergency medical response under hazardous conditions. One common staffing model for small combination departments is assignment of a single paid firefighter to drive/operate apparatus that is met at incident scenes by volunteers responding in private vehicles. This approach, used by this FD, may improve apparatus response times over those seen in all volunteer departments, but it has some drawbacks.³³

Recommendation #6 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, and



Fire Fighter Suffers Probable Heart Attack at Condominium Fire - South Carolina

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.^{31,34} 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.²⁹ The Fire Department should review these materials to identify applicable elements.

REFERENCES

1. Meyerburg RJ, Castellanos A [2001]. Cardiovascular collapse, cardiac arrest, and sudden cardiac death. In: Braunwald E, Fauci AS, Kasper DL, Hauser SL, Longo DL, Jameson JL, eds. *Harrison's principles of internal medicine*. 15th ed. New York: McGraw Hill, pp. 228-233.
2. American Heart Association. Risk factors and coronary heart disease (AHA scientific position). Available at <http://www.americanheart.org/presenter.jhtml?identifier=235>. Accessed September 2002.
3. Fauci AS, Braunwald E, Isselbacher KJ, et al. [1998]. *Harrison's principles of internal medicine*. 14th ed. New York: 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. Kondo NI, Muller JE [1995]. Triggering of acute myocardial infarction. *J Cardiovasc Risk* 2:499-504.
7. Opie LH [1995]. New concepts regarding events that lead to myocardial infarction. *Cardiovasc Drugs Ther* 9 Suppl 3:479-487.
8. Gledhill N, Jamnik, VK [1992]. Characterization of the physical demands of firefighting. *Can J Spt Sci* 17(3):207-213.
9. Barnard RJ, Duncan HW [1975]. Heart rate and ECG responses of fire fighters. *J Occup Med* 17:247-250..
10. 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.
11. Lemon PW, Hermiston RT [1977]. The human energy cost of fire fighting. *J Occup Med* 19:558-562
12. 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.
13. Mittleman MA, Maclure M, Tofler GH, et al. [1984]. Triggering of acute myocardial infarction by heavy physical exertion. *N Eng J Med* 311:874-877.
14. Siscovick DS, Weiss NS, Fletcher RH, Lasky T [2000]. The incidence of primary cardiac arrest during vigorous exercise. *N Eng J Med* 343:1555-1561.
15. Tofler GH, Muller JE, Stone PH, et al. [1992]. Modifiers of timing and possible triggers of acute myocardial infarction in the thrombolysis in



Fire Fighter Suffers Probable Heart Attack at Condominium Fire - South Carolina

- myocardial infarction phase II (TIMI II) study group. *J Am Coll Cardiol* 20:1049-1055.
16. Albert CM, Mittleman MA, Chae CU, et al. [2000]. Triggering of sudden death for cardiac causes by vigorous exercise. *N Eng J Med* 343:1555-1561.
17. Mittleman MA, Maclure M, Tofler GH, et al. [1984]. Triggering of acute myocardial infarction by heavy physical exertion. *N Eng J Med* 311:1677-1683.
18. 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.
19. Ainsworth BE, Haskell WL, Leon AS, et al. [1993]. Compendium of physical activities: classification of energy costs of human physical activities. *Med Sci Sports Exer* 25:71-80.
20. Sharkey BJ [1997]. Fitness and work capacity. 2nd ed. Technical Report 9751-2814-MTDC. Missoula(MT): United States Department of Agriculture, Forest Service, Missoula Technology and Development Center, p. 47.
21. Selwyn AP, Braunwald E [2001]. Ischemic heart disease. In: Braunwald E, Fauci AS, Kasper DL, Hauser SL, Longo DL, Jameson JL, eds. *Harrison's principles of internal medicine*. 15th ed. New York: McGraw Hill, pp. 1399-1410.
22. NFPA [2000]. NFPA 1582, Standard on medical requirements for fire fighters and information for fire department physicians. Quincy, MA: National Fire Protection Association.
23. ACSM's Guidelines for exercise testing & prescription [1995]. 5th ed. Baltimore, MD: Williams and Wilkins.
24. Sparks, PJ [1987]. Minimum medical standards for firefighters. Olympia WA: Association of Washington Cities.
25. O'Connell ER, Thomas PC, Cady LD, Karwasky RJ []. Energy costs of simulated stair climbing as a job-related task in fire fighting. *J Occup Med* 28:282-284.
26. Doolittle TL [1979]. Validation of physical requirements for firefighters. Seattle, WA: Seattle Fire Department.
27. Jacobs DT [1976]. Physical fitness and the fire services. Boston, MA: National Fire Protection Association.
28. Lemon PWR, Hermiston RT []. The human energy cost of fire fighting. *J Occup Med*, 19:558-562.
29. International Association of Fire Fighters, International Association of Fire Chiefs [2000]. The fire service joint labor management wellness/fitness initiative. Washington, D.C.: International Association of Fire Fighters, International Association of Fire Chiefs.
30. 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.
31. NFPA [1997]. NFPA 1500, Standard on fire department occupational safety and health program. Quincy, MA: National Fire Protection Association.
32. NFPA [2001]. NFPA 1710, Standard for the organization and deployment of fire suppression operations, emergency medical operations, and



Fire Fighter Suffers Probable Heart Attack at Condominium Fire - South Carolina

special operations to the public by career fire departments. Quincy, MA: National Fire Protection Association.

33. NFPA [1981]. Reduced staffing: at what cost. Fire Service Today. September 1981.

34. 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; Scott Jackson, RN, MSN, Occupational Health Nurse Practitioner; and Tom Hales, MD, MPH. Mr. Baldwin, Mr. Jackson, and Dr. Hales are with the NIOSH Fire Fighter Fatality Investigation and Prevention Program, Cardiovascular Disease Component, located in Cincinnati, Ohio.