



## **Fire Apparatus Operator Suffers Sudden Cardiac Death After Responding to Twelve Calls – Georgia**

### **SUMMARY**

On July 6th and 7th, 2005, a 54-year-old male career Fire Apparatus Operator (FAO) responded to 12 calls, 10 of which resulted from a tropical storm. Four calls involved removing tree limbs from the roadway. As he returned to the station after the last call, the FAO collapsed inside the cab of the engine. An ambulance was requested as crew members assessed the FAO and began cardiopulmonary resuscitation (CPR) and advanced life support (ALS) treatment. The ambulance transported the FAO to the hospital's emergency department where CPR and ALS treatment continued for an additional 24 minutes. Despite this treatment, the FAO died. The death certificate and the autopsy, completed by the County Medical Examiner, listed "cardiac dysrhythmia due to atherosclerotic coronary artery disease (CAD)" as the cause of death. The NIOSH investigator concluded that the physical stress of responding to 12 calls, including tree limb removal, and the presence of his underlying atherosclerotic cardiovascular disease probably contributed to the FAO's sudden cardiac death.

NIOSH investigators offer the following recommendations to prevent similar incidents and to address general safety and health issues:

*Perform pre-placement and periodic medical evaluations consistent with NFPA 1582 guidelines.*

*Ensure that fire fighters are cleared for duty by a physician knowledgeable about the physical demands of firefighting, the personal protective equipment used by fire fighters, and the various components of the National Fire Protection Association (NFPA) Standard 1582, Standard on Comprehensive Occupational Medical Program for Fire Departments.*

*Perform symptom-limiting exercise stress tests on members at high risk for CAD.*

*Provide fire fighters with medical evaluations and clearance to wear self-contained breathing apparatus (SCBAs).*

*Develop a structured wellness/fitness program for fire fighters to reduce risk factors for cardiovascular disease and improve cardiovascular capacity.*

### **INTRODUCTION & METHODS**

On July 7, 2005, a 54-year-old male FAO suffered sudden cardiac death while returning to his station after the 12<sup>th</sup> call of his shift. Despite CPR and ALS treatment, he died. NIOSH was notified of this fatality on July 7, 2005 by the United States Fire Administration. NIOSH contacted the affected fire department on July 29, 2005 to obtain further information, and on June 20, 2006 to initiate the investigation. On August 9, 2006, a Safety and Occupational Health Specialist from the NIOSH Fire Fighter Fatality Investigation

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 Web site at

[www.cdc.gov/niosh/fire](http://www.cdc.gov/niosh/fire)  
or call toll free **1-800-35-NIOSH**



***Fire Apparatus Operator Suffers Sudden Cardiac Death After Responding to Twelve Calls – Georgia***

Team traveled to Georgia to conduct an on-site investigation of the incident.

During the investigation, NIOSH personnel interviewed the following people:

- Deputy Fire Chief
- Crew members
- FAO's wife

NIOSH personnel reviewed the following documents:

- Fire Department incident reports
- Fire Department training records
- Fire Department annual 2005 response report
- Fire Department standard operating guidelines
- Ambulance reports
- Hospital records
- Death certificate
- Autopsy report
- Primary care provider records

## **INVESTIGATIVE RESULTS**

On July 6, 2005, the FAO arrived for duty at 1100 hours and was assigned as the apparatus operator of Engine 3 (staffed with the FAO, a Lieutenant, and a Fire Fighter/Paramedic). He normally arrived for duty at 0700 hours but he made an urgent doctor's appointment due to abdominal pain. Throughout the day the crew performed routine station duties. Engine 3 was dispatched to two medical calls: one at 1727 hours and one at 2014 hours. Engine 3 was cancelled en route to the first call; no patient was located on the second call. That evening, a tropical storm hit the area, downing many trees and electrical utility lines. Between 2230 hours on July 6<sup>th</sup> and 0116 hours on July 7<sup>th</sup>, Engine 3 responded to 10 calls, all relating to the storm. The FAO (wearing full turnout gear) assisted in removing tree limbs

from the roadway at four of these calls, while rain and lightning continued.

The last call involved a tree down (0116 hours). The weather conditions at this time included a temperature of 72° Fahrenheit and 93% relative humidity. The FAO assisted in removing the tree limbs from the roadway. At 0135 hours, he removed his helmet, gloves, and turnout coat, entered Engine 3, and began to drive toward his fire station. Suddenly, he made a noise and slumped over the seat. The Lieutenant reached over and pulled on the air brake, stopping the Engine. The Lieutenant notified Dispatch, who summoned an ambulance at 0135 hours. The Lieutenant sat the FAO upright and opened his airway. The Fire Fighter-Paramedic assessed the FAO, finding him to be unresponsive to verbal commands, but slightly responsive to painful stimuli. The FAO was breathing at a rate of 10-12 breaths per minute and had a carotid pulse. Crew members gave the FAO oxygen via a non-rebreather mask. After several minutes, his respiration rate lowered to 5-6 breaths per minute. Shortly after that, the FAO stopped breathing and became pulseless. An automated external defibrillator (AED) was attached to the FAO and three shocks were administered. The Fire Fighter-Paramedic inserted a combi-tube (a type of breathing mask/tube) into the FAO's mouth as CPR was begun. At this point the AED delivered two additional shocks. Due to the severe weather conditions, the ambulance did not arrive at the scene until 12 minutes later (0147 hours).

Ambulance paramedics found the FAO to be unresponsive, not breathing, and pulseless with CPR in progress. The FAO was placed onto a long back board, onto a stretcher, and into the ambulance. The ambulance departed the scene en route to the Emergency Department at 0149 hours. En route, the combi-tube was removed and the FAO was intubated (a breathing tube inserted into the windpipe) while intravenous lines were placed and cardiac resuscitation medications were administered. A cardiac monitor was attached to the FAO revealing ventricular fibrillation (a heart rhythm incompatible with life); a shock was



*Fire Apparatus Operator Suffers Sudden Cardiac Death After Responding to Twelve Calls  
– Georgia*

delivered. Cardiac pacing was attempted at a level of 100 milliamps at 80 beats per minute; capture was accomplished, but no effective heart beat could be ascertained. At 0205 hours, the ambulance arrived at the Emergency Department. Inside the Emergency Department, CPR and ALS treatment continued for an additional 23 minutes without improvement in the FAO's condition. He was pronounced dead by the attending physician at 0228 hours; and resuscitation efforts were discontinued.

**Medical Findings.** The death certificate and the autopsy, completed by the County Medical Examiner, listed "cardiac dysrhythmia due to atherosclerotic CAD" as the cause of death. Pertinent findings from the autopsy, performed on July 7, 2005, included the following:

- Atherosclerotic CAD
  - Variable calcific atherosclerosis of the left anterior descending coronary artery with a 90% blockage
  - Variable calcific atherosclerosis of the right coronary artery with a 40% blockage
- Cardiomegaly (enlarged heart: heart weighed 660 grams [normal <400 grams])<sup>1</sup>
  - Left ventricular hypertrophy with:
    - a left ventricular wall thickness of 1.8 centimeters (cm) (normal is 0.6 -1.1 cm)<sup>2</sup>
    - an interventricular septal wall thickness of 1.8 cm (normal is 0.6-1.1 cm)<sup>2</sup>
- Microscopic examination of the left ventricle revealed "patchy transmural myocardial fibrosis." "Similar but lesser changes were noted in the right ventricular myocardium, where fibrosis was primarily perivascular."
- No evidence of thromboemboli in the pulmonary arteries
- Negative drug and alcohol tests

On autopsy, the FAO weighed 278 pounds and was 72 inches tall, giving him a body mass index of 37.69 kilograms per square meter (kg/m<sup>2</sup>). A body

mass index >30.0 kg/m<sup>2</sup> is considered obese.<sup>3</sup> He had seven CAD risk factors: increasing age, male gender, family history, high blood pressure (hypertension) (diagnosed in 1992), obesity (diagnosed in 1992), high blood lipids (diagnosed in 1999), and diabetes (diagnosed in 2004).

In 1999, at the age of 48, the FAO was hospitalized for a myocardial infarction (heart attack). He underwent cardiac catheterization and two arterial stents were subsequently placed in his coronary arteries. Medical follow-up included an imaging stress test in 2000, in which the FAO completed 5 minutes of the Bruce Protocol, increasing his heart rate from 62 beats per minute (bpm) to 122 bpm and achieving 5 metabolic equivalents (METs). While no reason for stopping was mentioned in the medical records, there was no evidence of ischemia and the stress test was deemed normal by the cardiologist. An echocardiogram in 2001 revealed normal heart chamber size and a normal left ventricular ejection fraction of 55%-60%. In 2002, a cardiac stress test with dobutamine revealed borderline ST segment depressions, but no evidence of current myocardial ischemia.

At the time of his death, the FAO was taking anti-hypertensive and antilipemic prescription medications. According to his wife and crew members, he did not express any symptoms of cardiac-related problems during the days or months prior to his death. However, on the day before his death, he had complained of right-side abdominal pain. He had a transabdominal ultrasound, which revealed fatty infiltration of the liver. He returned to duty following the ultrasound.

## **DESCRIPTION OF THE FIRE DEPARTMENT**

At the time of the NIOSH investigation, this career Fire Department consisted of 101 uniformed personnel, served a population of 79,500 in a 132-square-mile area, and had seven fire stations.



## *Fire Apparatus Operator Suffers Sudden Cardiac Death After Responding to Twelve Calls – Georgia*

Employment and Training. The Fire Department requires the following of all fire fighter applicants:

- complete an application
- possess a valid State driver's license
- possess a high school diploma or equivalent
- pass a physical agility test
- pass a background check
- pass a written aptitude examination
- pass an oral interview

The applicant is then offered employment and must pass a drug screen and a post-offer/pre-placement medical evaluation. The fire fighter is placed into a State Basic Fire Fighter Training Course which trains the fire fighter to the National Professional Qualifications Fire Fighter I level. The fire fighter is then assigned to a shift and works 24 hours on-duty (0700 hours to 0700 hours) and 48 hours off-duty.

The FAO was certified as a Fire Fighter III, Emergency Medical Technician-Paramedic, Driver/Operator, Instructor, Hazardous Materials Technician, and Wildland Fire Fighter. He had 19 years of firefighting experience and had worked as a Paramedic for local ambulance services for 13 years.

Pre-placement Medical Evaluation. Contents of the pre-placement medical evaluation are as follows:

- Complete medical history
- Physical examination
- Vital signs
- Vision screening
- Audiogram
- Urinalysis
- Urine drug screen

A County physician performs the medical evaluations and forwards the clearance-for-duty decision through the County Human Resources Office to the

Fire Department, who makes the final determination for clearance for duty.

Periodic Evaluations. No annual Fire Department medical evaluations are offered. However, the County offers an annual health fair which includes vision screening and blood tests. Members may elect to receive a medical evaluation from their primary care physician with a minimal co-pay as part of the County fire fighter insurance plan. Medical clearance for SCBA use is not required. A return-to-duty medical clearance is required from the fire fighter's primary care physician and the Worker's Compensation physician for duty-related injuries. If a non-duty-related illness prevents a fire fighter from performing his or her duty, a return-to-duty clearance may be required from the fire fighter's primary care physician and the County physician, who makes the final clearance decision. Primary care physicians are given a "Fitness for Duty Report" that describes firefighting duties and requires the primary care physician to determine if the fire fighter can perform those duties.

Health/Wellness. An annual physical agility test (hose carry, hose hoist, ladder climb, advance charged hoseline, and victim carry) is required for members. There is a voluntary wellness/fitness program, with each shift having time set aside for physical fitness exercise. Exercise equipment (strength and aerobic) is available in the fire stations.

## **DISCUSSION**

CAD and the Pathophysiology of Sudden Cardiac Death. In the United States, CAD (atherosclerosis) is the most common risk factor for cardiac arrest and sudden cardiac death.<sup>4</sup> Risk factors for its development include increasing age, male gender, family history, tobacco smoking, diabetes, high blood cholesterol, hypertension, and physical inactivity/obesity.<sup>5</sup> The FAO had seven risk factors for CAD: increasing age, male gender, family history, diabetes, high blood



*Fire Apparatus Operator Suffers Sudden Cardiac Death After Responding to Twelve Calls  
– Georgia*

cholesterol, hypertension, and physical inactivity/obesity. He had CAD based on his cardiac catheterization in 1999 and his autopsy report.

Narrowing of the coronary arteries by atherosclerotic plaques occurs over many years, typically decades.<sup>6</sup> However, the growth of these plaques probably occurs in a nonlinear, often abrupt fashion.<sup>7</sup> 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.<sup>8</sup> This sudden blockage is primarily due to blood clots (thromboses) forming on the top of atherosclerotic plaques.

Establishing the occurrence of a heart attack requires any of the following: characteristic electrocardiogram (EKG) changes, elevated cardiac enzymes, or coronary artery thrombus. In the FAO's case, he never regained a heart rhythm on which an EKG could reveal characteristic changes, cardiac enzyme testing was not performed (but we would not expect the enzymes to become positive for at least 4 hours post-heart attack),<sup>9</sup> and no thrombus was found at autopsy. However, not all heart attacks have an associated coronary artery thrombus. It is possible the FAO suffered a heart attack, but this cannot be confirmed.

Firefighting is widely acknowledged to be one of the most physically demanding and hazardous of all civilian occupations.<sup>10</sup> Firefighting activities are strenuous and often require fire fighters to work at near maximal heart rates for long periods. Even when energy costs are moderate (as measured by oxygen consumption), and work is performed in a thermoneutral environment, heart rates may be high (over 170 bpm), owing to the insulative properties of the personal protective clothing.<sup>11</sup> Epidemiologic studies have found that heavy physical exertion sometimes immediately precedes and triggers the onset of acute heart attacks.<sup>12-15</sup> The FAO responded to 12 calls, removing tree limbs from the roadway at 4 of those calls, while wearing full turnout gear. This is considered a light to moderate level of physical exertion.<sup>10,16</sup> The physical stress of

performing these tasks and the presence of underlying atherosclerotic CAD, probably contributed to this fire fighter's sudden cardiac death.

*Cardiomegaly and Left Ventricular Hypertrophy.* On autopsy, the FAO had an enlarged heart and left ventricular hypertrophy, which was probably due to his long-standing hypertension or chronic myocardial ischemia. Both conditions increase the risk for sudden cardiac death. The NIOSH investigator concludes that the FAO had a cardiac arrhythmia associated with cardiomegaly, left ventricular hypertrophy, a heart attack, or any of these in combination.

Histology findings (patchy transmural fibrosis) at autopsy did not reveal sufficient fibrosis to be consistent with a dilated or hypertrophic cardiomyopathy.

*Occupational Medical Standards for Structural Fire Fighters.* To reduce the risk of sudden cardiac arrest or other incapacitating medical conditions among fire fighters, the NFPA developed NFPA 1582.<sup>17</sup> The 2003 edition of NFPA 1582 recommends asymptomatic fire fighters with two or more risk factors for CAD be screened for obstructive CAD by an exercise stress test. NFPA defines these CAD risk factors as: family history of premature cardiac event (first-degree relative <age 60), hypertension (diastolic blood pressure >90 mmHg), diabetes mellitus, cigarette smoking, and hypercholesterolemia (total blood cholesterol level >240 mg/dL).<sup>17</sup> This guidance is similar to recommendations from the American College of Cardiology (ACC)/American Heart Association (AHA) and the Department of Transportation (DOT) regarding exercise stress tests in asymptomatic individuals.<sup>18,19</sup> Since the FAO was over the age of 45 years and had four "NFPA" CAD risk factors (family history, high blood pressure, diabetes, and hypercholesterolemia), an exercise stress test would have been consistent with NFPA, ACC/AHA, and DOT guidelines.

In the NFPA 1582 annex, submaximal exercise stress tests (85% of maximal heart rate) using a treadmill, bicycle, or stair climber are allowed.<sup>17</sup> Submaximal



## *Fire Apparatus Operator Suffers Sudden Cardiac Death After Responding to Twelve Calls – Georgia*

protocols have a predetermined end point, often defined as a peak heart rate of 120 beats per minute, or 70% of the predicted maximum heart rate, or a peak MET level of 5.<sup>18</sup> On this point, however, NFPA 1582 differs with the ACC/AHA. The ACC/AHA recommend a symptom-limiting maximal exercise stress test rather than an arbitrary percentage of predicted maximum heart rate (e.g., a submaximal test).<sup>18</sup> It is unclear why the exercise stress test of 2000 was stopped, but it appears that a submaximal exercise stress test was performed. Failure to achieve 5 METs is associated with poor exercise capacity and an increased risk for sudden cardiac death.<sup>18</sup> It is unclear why a submaximal (rather than a maximal) test was performed 13 months post-heart attack.

The FAO had a dobutamine exercise stress test in 2002 which revealed a borderline abnormality. Dobutamine is a chemical rather than an exercise test and is usually performed in individuals with very poor exercise capacity or joint problems. The FAO's dobutamine stress test showed a borderline ST segment depression (0.9 millimeters) in the inferior region of the heart which is suggestive of ischemia. However, due to: 1) the lack of angina during the exercise stress test, 2) no arrhythmias during the exercise stress test, and 3) only borderline ST segment depression, these changes were not felt to be due to ischemic CAD.

### **RECOMMENDATIONS**

NIOSH investigators offer the following recommendations to prevent similar incidents and to address general safety and health issues:

***Recommendation #1: Perform pre-placement and periodic medical evaluations consistent with NFPA 1582 guidelines.***

Guidance regarding the content and frequency of periodic medical evaluations and examinations for fire fighters can be found in NFPA 1582<sup>17</sup> and in the IAFF/IAFC Fire Service Joint Labor Management

*Wellness/Fitness Initiative.*<sup>20</sup> However, the Fire Department is not legally required to follow this standard or this initiative.

In addition to providing guidance on the frequency and content of the medical evaluation, NFPA 1582 provides guidance on medical requirements for people performing firefighting tasks. Applying NFPA 1582 involves legal issues, so it should be carried out in a **confidential, nondiscriminatory** manner. Appendix B of NFPA 1582 provides guidance for FD 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 addresses these issues in Chapter 8-7.1 and 8-7.2.<sup>21</sup>

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) provide permanent alternate duty positions or other supportive and/or compensated alternatives if the fire fighter is not medically qualified to return to active firefighting duties.**

***Recommendation #2: Ensure that fire fighters are cleared for duty by a physician knowledgeable about the physical demands of firefighting, the personal protective equipment used by fire fighters, and the various components of the NFPA Standard 1582, Standard on Comprehensive Occupational Medical Program for Fire Departments.***

The annual medical evaluation recommended by NFPA 1582 can be conducted by the fire fighter's primary care physician, however, the results must be communicated to the County physician, who makes the final determination for clearance for duty.



***Fire Apparatus Operator Suffers Sudden Cardiac Death After Responding to Twelve Calls  
– Georgia***

For fire fighters with a previous history of a heart attack, NFPA 1582 recommends restricted duty, if any of the following symptoms are present:

- (1) Current angina pectoris, even if relieved by medication
- (2) Persistent significant stenosis in any coronary artery (>70% lumen diameter narrowing) following treatment
- (3) Lower than normal left ventricular ejection fraction as measured by radionuclide scan, contrast ventriculography, or echocardiography
- (4) Maximal exercise tolerance of <42 milliliters (mL) of oxygen per minute per kg or <12 metabolic equivalents (METS)
- (5) Exercise-induced ischemia or ventricular arrhythmias observed by radionuclide stress test during an evaluation reaching at least a 12-METS workload
- (6) History of MI, angina, or CAD with persistence of modifiable risk factor(s) for acute coronary plaque rupture

While the FAO did not have recurring angina or reduced left ventricular ejection fraction, he had not exercised to a 12-MET level and had a history of persistent modifiable risk factors (hypertension, high blood cholesterol, and diabetes).

***Recommendation #3: Perform symptom-limiting exercise stress tests on members at high risk for CAD.***

The Fire Department does not require an exercise stress test. The AHA suggests that “on the basis of prognostic considerations, asymptomatic male patients older than 45 years with one or more risk factors (hypercholesterolemia, hypertension, smoking, diabetes, or family history of premature CAD) may obtain

useful prognostic information from exercise testing.”<sup>18</sup> Had a more recent symptom-limiting exercise stress test been performed and the FAO’s underlying cardiac disease been further evaluated and treated, perhaps his SCD could have been prevented at this time.

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

The Occupational Safety and Health Administration (OSHA)’s Revised Respiratory Protection Standard requires employers to provide medical evaluations and clearance for employees using respiratory protection.<sup>22</sup> Such employees include fire fighters who utilize SCBA in the performance of their duties. These clearance evaluations are required for private industry employees and public employees in States operating OSHA-approved State plans. However, Georgia is not a State-plan State and public sector employers are not required to comply with OSHA standards. Regardless, the NIOSH investigator recommends voluntary compliance.

***Recommendation #5: Develop a structured wellness/fitness program for fire fighters to reduce risk factors for cardiovascular disease and improve cardiovascular capacity.***

Currently the FD has a voluntary wellness/fitness program which includes exercise equipment available in the fire stations and time allotted to exercise. Additionally, the FD requires an annual physical agility test for all members. However, NIOSH recommends a formal, structured wellness/fitness program to ensure all members receive the benefits of physical exercise.

Physical inactivity is the most prevalent modifiable risk factor for CAD in the United States. Physical inactivity, or lack of exercise, is associated with other risk factors, including obesity and diabetes.<sup>23</sup> NFPA 1500 requires a wellness program that provides health promotion activities for preventing health problems and enhancing overall well-being.<sup>21</sup> Wellness pro-



## *Fire Apparatus Operator Suffers Sudden Cardiac Death After Responding to Twelve Calls – Georgia*

grams have been shown to be cost effective, typically by reducing the number of work-related injuries and lost work days.<sup>24-26</sup> A similar cost savings has been reported by the wellness program at the Phoenix Fire Department, where a 12-year commitment has resulted in a significant reduction in their disability pension costs.<sup>27</sup> Guidance for implementation and components of a wellness/fitness program may be found in NFPA 1583, *Standard on Health-Related Fitness Programs for Fire Fighters*,<sup>28</sup> and in the IAFF/IAFC, *Fire Service Joint Labor Management Wellness/Fitness Initiative*.<sup>20</sup> The FD should work with its members to develop and implement any type of wellness/fitness program.

## REFERENCES

1. Siegel RJ [1997]. Myocardial hypertrophy. In: Bloom S, ed. *Diagnostic criteria for cardiovascular pathology acquired diseases*. Philadelphia, PA: Lippencott-Raven, pp. 55-57.
2. Armstrong WF, Feigenbaum H [2001]. Echocardiography. In: Braunwald E, Zipes DP, Libby P, eds. *Heart disease: a text of cardiovascular medicine*. 6<sup>th</sup> ed. Vol. 1. Philadelphia, PA: W.B. Saunders Company, p. 167.
3. National Heart Lung Blood Institute [2003]. Obesity education initiative. [<http://www.nhlbisupport.com/bmi/bmicalc.htm>]. Date accessed: December 2006.
4. Meyerburg RJ, Castellanos A [2005]. Cardiovascular collapse, cardiac arrest, and sudden cardiac death. In: Kasper DL, Braunwald E, Fauci AS, Hauser SL, Longo DL, Jameson JL, eds. *Harrison's principles of internal medicine*. 16<sup>th</sup> ed. New York: McGraw Hill, pp. 1618-1624.
5. AHA [1998]. AHA scientific position, risk factors for coronary artery disease. Dallas, TX: American Heart Association.
6. Libby P [2005]. The pathogenesis of atherosclerosis. In: Kasper DL, Braunwald E, Fauci AS, Hauser SL, Longo DL, Jameson JL, eds. *Harrison's principles of internal medicine*. 16<sup>th</sup> ed. New York: McGraw-Hill, pp. 1425-1430.
7. Shah PK [1997]. Plaque disruption and coronary thrombosis: new insight into pathogenesis and prevention. *Clin Cardiol* 20(11 Suppl2):II-38-44.
8. Fuster V, Badimon JJ, Badimon JH [1992]. The pathogenesis of coronary artery disease and the acute coronary syndromes. *N Engl J Med* 326:242-250.
9. AHA [2006]. Blood tests for rapid detection of heart attacks. Dallas, TX: American Heart Association. [<http://www.americanheart.org/pre-senter.jhtml?identifier=4477>]. Date accessed: December 2006.
10. Gledhill N, Jamnik VK [1992]. Characterization of the physical demands of firefighting. *Can J Spt Sci* 17(3):207-213.
11. Smith DL, Petruzzello SJ, Kramer JM, Warner SE, Bone BG, Misner JE [1995]. Selected physiological and psychobiological responses to physical activity in different configurations of firefighting gear. *Ergonomics* 38(10):2065-2077.
12. Willich SN, Lewis M, Lowel H, Arntz HR, Schubert F, Schroder R [1993]. Physical exertion as a trigger of acute myocardial infarction. *N Engl J Med* 329:1684-1690.
13. Mittleman MA, Maclure M, Tofler GH, Sherwood JB, Goldberg RJ, Muller JE [1993]. Triggering of acute myocardial infarction by heavy physical exertion. *N Engl J Med* 329:1677-1683.
14. Siscovick DS, Weiss NS, Fletcher RH, Lasky T [1984]. The incidence of primary cardiac arrest during vigorous exercise. *N Engl J Med* 311:874-877.





*Fire Apparatus Operator Suffers Sudden Cardiac Death After Responding to Twelve Calls  
– Georgia*

15. Toffler GH, Muller JE, Stone PH, Forman S, Solomon RE, Knatterud GL, Braunwald E [1992]. Modifiers of timing and possible triggers of acute myocardial infarction in the Thrombolysis in Myocardial Infarction Phase II (TIMI II) Study Group. *J Am Coll Cardiol* 20:1049-1055.
16. American Industrial Hygiene Association Journal [1971]. Ergonomics guide to assessment of metabolic and cardiac costs of physical work. *Am Ind Hyg Assoc J* 32:560-564.
17. NFPA [2003]. NFPA 1582: Standard on comprehensive occupational medical program for fire departments. Quincy, MA: National Fire Protection Association.
18. Gibbons RJ, Balady GJ, Bricker JT, Chaitman BR, Fletcher GF, Froelicher VF, Mark DB, McCallister BD, Mooss AN, O'Reilly MG, Winters WL Jr. [2002]. ACC/AHA 2002 guideline update for exercise testing: a report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines (Committee on Exercise Testing). [<http://content.onlinejacc.org/cgi/content/short/40/8/1531>]. Date accessed: December 2006.
19. U.S. DOT [2002]. Cardiovascular advisory panel guidelines for the medical examination of commercial motor vehicle drivers. Washington, DC: Department of Transportation; Federal Motor Carrier Safety Administration (FMCSA), Publication No. FMCSA-MCP-02-002. [<http://www.fmcsa.dot.gov/documents/cardio.pdf>]. Date accessed: December 2006.
20. IAFF, IAFC [2000]. The fire service joint labor management wellness/fitness initiative. Washington, DC: International Association of Fire Fighters, International Association of Fire Chiefs.
21. NFPA [2002]. NFPA 1500: Standard on fire department occupational safety and health program. Quincy, MA: National Fire Protection Association.
22. CFR. 29 CFR 1910.134, Respiratory protection. Code of Federal Regulations. Washington, DC: U.S. Government Printing Office, Office of the Federal Register.
23. Plowman SA, Smith DL [1997]. Exercise physiology: for health, fitness and performance. Boston, MA: Allyn and Bacon.
24. Maniscalco P, Lane R, Welke M, Mitchell J, Husting L [1999]. Decreased rate of back injuries through a wellness program for offshore petroleum employees. *J Occup Environ Med* 41:813-820.
25. Stein AD, Shakour SK, Zuidema RA [2000]. Financial incentives, participation in employer sponsored health promotion, and changes in employee health and productivity: HealthPlus health quotient program. *J Occup Environ Med* 42:1148-1155.
26. Aldana SG [2001]. Financial impact of health promotion programs: a comprehensive review of the literature. *Am J Health Promot* 15:296-320.
27. Unpublished data [1997]. City Auditor, City of Phoenix, AZ. Disability retirement program evaluation. January 28, 1997.
28. NFPA [2000]. NFPA 1583: Standard on health-related fitness programs for fire fighters. Quincy, MA: National Fire Protection Association.



*Fire Apparatus Operator Suffers Sudden Cardiac Death After Responding to Twelve Calls  
– Georgia*

**INVESTIGATOR INFORMATION**

This investigation was conducted by and the report written by:

*Tommy N. Baldwin, MS*  
Safety and Occupational Health Specialist

Mr. Baldwin, a National Association of Fire Investigators (NAFI) Certified Fire and Explosion Investigator, an International Fire Service Accreditation Congress (IFSAC) Certified Fire Officer I, a Kentucky Certified Fire Fighter and Emergency Medical Technician (EMT), and a former Fire Chief, is with the NIOSH Fire Fighter Fatality Investigation and Prevention Program, Cardiovascular Disease Component located in Cincinnati, Ohio.

**U. S. Department of Health and Human Services**  
Public Health Service  
Centers for Disease Control and Prevention  
National Institute for Occupational Safety and Health  
4676 Columbia Parkway, MS\_C-13  
Cincinnati, OH 45226-1998

---

**OFFICIAL BUSINESS**

Penalty for private use \$300



**Delivering on the Nation's promise:  
Safety and health at work for all people  
through research and prevention**