



Battalion Chief Dies as a Result of a Heart Attack that Occurred During Training - Illinois

SUMMARY

On February 25, 1998, a 62-year-old male Battalion Chief was found unconscious in his car shortly after performing a training exercise while wearing full turnout gear, including his self-contained breathing apparatus. Resuscitation efforts at the scene, during transport, and at the hospital were unsuccessful. The death certificate and autopsy listed coronary atherosclerosis as the cause of death.

The following recommendations address preventative measures that have been recommended by other agencies to reduce, among other things, the risk of on-duty heart attacks and cardiac arrests among fire fighters. These recommendations have not been evaluated by NIOSH, but represent research presented in the literature, consensus votes of technical committees of the National Fire Protection Association (NFPA), or products of labor/management technical committees within the fire service. This preventative strategy consists of: 1) minimizing physical stress on fire fighters; 2) screening to identify and subsequently rehabilitate high risk individuals; and 3) encouraging increased individual physical capacity (fitness). The Department where this Battalion Chief worked has already taken steps to implement these recommendations.

- ***Provide fire fighters with lighter-weight protective equipment to reduce the physical demands placed upon fire fighters.***
- ***Implement an overall health and safety program such as the one recommended in NFPA 1500, Standard on Fire Department Occupational Safety and Health Program.***

- ***Providing fire fighters with periodic medical evaluations, including a exercise cardiac stress test for those employees above the age of 40 as recommended by NFPA 1582, Standard of Medical Requirements for Fire Fighters.***
- ***Initiating a wellness/fitness program to reduce risk factors for cardiovascular disease and improve cardiovascular capacity such as the IAFF/IAFC Wellness-Fitness Initiative.***

INTRODUCTION & METHODS

On February 25, 1998, a 62-year-old male Battalion Chief collapsed in his car shortly after performing a training exercise. The cause of death listed on the death certificate and autopsy was coronary atherosclerosis. NIOSH notified the University of Illinois, Great Lakes Center for Occupational and Environmental Safety and Health (UIC-GLC), Health Hazard Evaluation Program of this fatality in November of 1998. A UIC-GLC industrial hygienist telephoned the Fire Department on November 25,

The Fire Fighter Fatality Investigation and Prevention Program

is conducted by the National Institute for Occupational Safety and Health (NIOSH). The purpose of the program is to determine factors that cause or contribute to fire fighter deaths suffered in the line of duty.

Identification of causal and contributing factors enable researchers and safety specialists to develop strategies for preventing future similar incidents. To request additional copies of this report (specify the case number shown in the shield above), other fatality investigation reports, or further information, visit the Program Website at:

<http://www.cdc.gov/niosh/firehome.html>

or call toll free 1-800-35-NIOSH



Fatality Assessment and Control Evaluation
Investigative Report #99F-20

Battalion Chief Dies as a Result of a Heart Attack that Occurred During Training - Illinois

1998 to initiate the investigation. On December 21, 1998, an industrial hygienist and physician from the UIC-GLC NIOSH Fire Fighter Fatality Investigation Team traveled to Illinois to conduct an on-site investigation of the incident.

UIC-GLC personnel began the investigation by meeting with and interviewing officers and co-workers from the employing Fire Department and the training officers of the neighboring Fire Department where the deceased Chief was training. During the on-site investigation UIC-GLC reviewed:

- Existing Fire Department/City investigative records, including incident reports, coworker statements, dispatch records, etc.;
- Departmental policies and procedures;
- Respirator and fire fighter clearance summary reports;
- Autopsy report;
- Death certificate;
- Reviewed photographs of the training site; and
- Contacted the private physician of the deceased Battalion Chief.

INVESTIGATIVE RESULTS

Training Scene Response. On February 25, 1998, five fire fighters from the affected Fire Department traveled to a temporary training site in a neighboring community, to perform their annual Consumption Test involving simulation of fire fighting activities. This test is performed in full turnout gear with a hood covering the head to simulate lack of visibility in smoke-filled environments (Photo 1). An obstacle course (Photos 2 and 3) designed to mimic conditions during structural fire fighting is used and fire fighter blood pressure, pulse rate, respiratory rate, and pulse oximetry (test to measure blood oxygenation) are monitored. In addition, self-contained breathing apparatus (SCBA) tank pressure is measured to estimate air consumption (Table 1). During the course

of the test, the air tanks are changed as needed. The affected Fire Protection District uses positive pressure/pressure demand full-face piece SCBA with high pressure tanks (4500 PSI) rated at 30 minutes of breathing air.

Table 1.

SCBA Consumption Report			
	Start	End	Elapsed Time
Time	13:50	14:43	53 Min.
Blood Pressure	198/100	190/94	
Pulse	88	126	
Respiratory Rate	16	28	
	Pulse Oximetry	PSI Used	Time
Tank 1	98		
Tank 2	95		
Tank 3	96	3200	16 Min.

This training is not required for Battalion Chiefs, however, the victim decided to voluntarily participate. The Battalion Chief and a Lieutenant were the first two-person team through the course. They were not hurried and the Lieutenant led with the Battalion Chief following. Throughout the course the two firefighters kept in constant voice and direct contact with each other. They changed their tanks twice, at the same time, with the last change near the end of the course. Completion time was 53 minutes. As shown in Table 1, vital signs were measured at both the beginning and end of the course. After completing the course, the Battalion Chief appeared tired, doffed his gear, drank some water, and spent 15 to 20 minutes talking with the Lieutenant while resting and sitting on the floor. The Battalion Chief was observing the next team proceeding through the course when he received a page. He left the training area to answer the page from a cellular telephone in his car.



Fatality Assessment and Control Evaluation Investigative Report #99F-20

Battalion Chief Dies as a Result of a Heart Attack that Occurred During Training - Illinois

When the second team completed the course (approximately 25 minutes later), the Lieutenant went outside to return his gear to the truck and found the Battalion Chief unconscious in his car. He was seated in the driver's seat with his right leg in the car, his left foot on the ground and his left arm resting on his left leg while the car's engine was running. The car was equipped with lights and a siren, but they were not activated.

The following approximate time line related to the incident was abstracted from training reports and interviews:

Time	Activity/Event Summary
13:50 hours	Began Consumption Test and course
14:43 hours	Completed course, doffed gear, began rest period
15:00 hours	Second team begins Consumption Test and course
15:10 hours	Victim receives page and leaves facility for car
15:34 hours	Lieutenant finds the Battalion Chief unconscious.

EMS Response to the Battalion Chief's Medical Emergency. Fire fighters, certified as paramedics, reached the Battalion Chief within seconds of discovery and found him pulseless and not breathing. Within five minutes cardiopulmonary resuscitation (CPR) was begun. The Battalion Chief's rhythm of ventricular fibrillation was shocked twice but, unfortunately, converted to asystole. He was subsequently intubated, and intravenous administration of epinephrine and atropine were begun while continuing CPR. Despite CPR and advanced life support for two minutes in the field, for 4 minutes en-route to the hospital, and for 33 minutes in the hospital's emergency department, the Battalion Chief never regained consciousness and was pronounced dead at 1617 hours.

Medical Findings. The death certificate was completed by the medical examiner on 2/25/98. The immediate cause of death was listed as coronary atherosclerosis. An autopsy was performed by the medical examiner on 2/26/98. Pertinent findings were: "Extensive coronary artery atherosclerosis. The left anterior descending coronary artery contain(s) 90% stenosis by calcific atherosclerotic plaque formation. The right coronary artery contains 80% stenosis by calcific atherosclerotic plaque formation."

The Battalion Chief was in apparent good health prior to this incident. He did not smoke and was active in fitness training, weight lifting, and had a proper diet and good nutrition. In fact, co-workers described him as a fitness "buff" who worked out with weights, did cardiovascular exercises to keep in good physical condition, and watched his diet. He reported no symptoms suggestive of coronary artery disease, although 2 days prior to this incident, he complained of arm numbness following a weight lifting session at the gym. This arm numbness was considered musculoskeletal in origin, not a symptom of angina (chest pain due to decreased blood supply to the heart).

Medical records indicated the victim had at least one risk factor (increased blood cholesterol) for coronary artery disease. His last fire fighter physical evaluation was in November, 1997. At this time his cholesterol level was 213 [200 to 240 milligrams/deciliter (mg/dl) is considered borderline high]. In addition, he had a "low" high density lipoprotein (HDL) level of 32 mg/dl, resulting in an "elevated" Cholesterol/HDL ratio of 6.66. His low density lipoprotein (LDL) level was normal at 124 mg/dl. His electrocardiogram (EKG) did record an occasional premature ventricular contraction (PVC), but was otherwise normal. He had never been documented to have hypertension on previous evaluations. The examining physician recommended increased exercise and diet to treat his "borderline high" cholesterol.



Battalion Chief Dies as a Result of a Heart Attack that Occurred During Training - Illinois

FIRE DEPARTMENT DESCRIPTION, POLICIES, AND PROGRAMS

The Fire Department involved in this incident employs a total of 120 fire fighters serving 75,000 residents in an area of 38 square miles. The Department requires pre-employment and annual medical evaluations for fire fighting and SCBA usage. The District follows NFPA 1582 guidelines for their fitness-for-duty medical evaluations.

The Department also has a regular physical capacity evaluation program [Fire Fit Program] which consists of blood pressure and pulse recordings, a five-minute step test, sit-ups, push-ups, leg presses, bench presses and a grip test. In addition, the District provides programs for health maintenance, physical fitness, and critical-incident-stress debriefing.

Fire fighters below forty years of age complete the fire fit program every 4 years, and when over the age of 40 annually. An EKG is included in this screening for fire fighters over the age of fifty.

Records indicate that the Battalion Chief had last been tested for these clearances in November 1997, three months prior to the incident. These evaluations did not indicate an increased risk of CVD. His medical records indicated an elevated cholesterol which is a risk factor that would not be detected by the program in place at this time.

SERVICE HISTORY OF THE DECEASED FIRE FIGHTER

The victim received his paramedic certification in 1975 and began serving this District as a fire fighter since 1977. He was promoted to a Battalion Chief in 1987 and was a former member of a local volunteer Fire Department.

DISCUSSION

The victim had an unwitnessed cardiac arrest. Fire Fighters, trained as paramedics, found the victim in ventricular fibrillation (V.Fib.), an ineffective heart rhythm that, unless converted, is universally fatal. This arrhythmia (V.Fib.) is the most common type associated with cardiac arrest, occurring in 65-80% of all cardiac arrests.¹ In the United States, coronary artery disease (atherosclerosis) leading to a myocardial infarction (heart attack) is the most common risk factor for sudden cardiac death and cardiac arrest (80%). Risk factors for the development of atherosclerosis include increasing age, male gender, family history of CAD, smoking, high blood pressure, high blood cholesterol, obesity, physical inactivity, and diabetes.² The victim had a few of these risk factors, and had extensive atherosclerotic lesions in his coronary arteries on autopsy.

In the presence of atherosclerosis, cardiac stress due to mental or physical stress may be a factor in precipitating the chain of events leading to a heart attack. 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.³⁻⁶ Epidemiologic studies have found that heavy physical exertion sometimes immediately proceeds and triggers the onset of acute heart attacks.⁷⁻¹⁰

Fire fighters are exposed to a host of different chemicals during the course of fire fighting and during the clean up after the fire has been struck out. Some of these chemicals can increase cardiac ischemia at a time when maximum cardiac effort is necessary. These include carbon monoxide, methylene chloride, and various cellular asphyxiants. The stress response may also potentiate cardiac dysfunction. Thus, it is not a surprise that fire fighters have been found to be at increased risk of on-duty sudden cardiac death.¹¹⁻¹²



Battalion Chief Dies as a Result of a Heart Attack that Occurred During Training - Illinois

Screening fire fighters for risk factors for CAD, or for the presence of CAD directly with subsequent treatment and rehabilitation, should reduce the number of on-duty heart attacks and subsequent sudden cardiac deaths. This should include a blood pressure measurement, blood cholesterol, urine check for glucose (diabetes), counseling on a healthy diet, counseling on tobacco prevention, and promoting physical activity. The IAFF/IAFC Wellness-Fitness Initiative recommends an annual EKG and a test of aerobic capacity yearly regardless of age.¹³

The most common screening procedure for detecting underlying CAD is the exercise, or treadmill, stress test. Current NFPA guidelines recommend treadmill testing for fire fighters at age 40, or 35 for those with one or more risk factors for coronary artery disease.¹⁴ Used during the treadmill test, intravenous thallium administration, and/or right sided chest leads improve the accuracy of the procedure, but involve additional expense.¹⁵

Newer CAD screening tests include the electron beam (ultra-fast) CT scanning or the exercise Pulmonary Function/Cardiac Testing with a metabolic cart.¹⁶⁻¹⁸ It is reasonable in price and effective in the identification of intra arterial calcium and by inference plaque in symptomatic patients. There has not been enough experience with the test to recommend its use as a screening test for CAD among asymptomatic fire fighters.

The latter test, although expensive, gives direct readings of cardiac and pulmonary status with exercise, in addition to the degree of physical fitness. This is quite effective in determining early respiratory disease or decreases in physical fitness. The expense of the equipment to this point has prevented its wide use in the field.

RECOMMENDATIONS AND DISCUSSION

The following recommendations address preventative measures that have been recommended by other agencies to reduce, among other things, the risk of on-duty heart attacks and cardiac arrests among fire fighters. These recommendations have not been evaluated by NIOSH, but represent research presented in the literature, consensus votes of technical committees of the National Fire Protection Association (NFPA), or products of labor/management technical committees within the fire service. This preventative strategy consists of: 1) minimizing physical stress on fire fighters; 2) screening to identify and subsequently rehabilitate high risk individuals; and 3) encouraging increased individual physical capacity (fitness). The district where this Battalion Chief worked has already taken steps to implement these recommendations.

Recommendation #1: Provide fire fighters with lighter-weight protective equipment to reduce the physical demands placed upon fire fighters.

Protective clothing and respirators worn by fire fighters significantly increase stress on the cardiovascular, respiratory, and temperature regulating systems of the body, decreasing exercise tolerance time by as much as 95.6%, and increasing heart rates¹⁹⁻²¹. Significant and potentially dangerous cardiovascular stress from wearing fire fighter protective gear has been noted even at low intensities²⁰. Such increased stress is attributed to the physiological demands of carrying such heavy equipment, as well as reduced capability for evaporative cooling.

Full turnout gear worn by these fire fighters in this Department probably weighs 60 pounds when dry, and even more when wet. The weight of the full ensemble could be reduced by as much as 16 pounds if fire fighters were equipped with lighter-weight low-profile SCBAs. The Department currently uses



Battalion Chief Dies as a Result of a Heart Attack that Occurred During Training - Illinois

SCBAs with high-profile cylinders. The total unit weighs approximately 35 pounds. Use of newer technology, such as commercially available SCBAs that weigh 19 pounds when equipped with a 30-minute carbon cylinder, would: 1) reduce physical stress on the fire fighter; 2) provide better physical clearance for fire fighters in close situations; and 3) reduce the need to conduct some fire ground activities without the use of SCBAs, thus reducing fire fighter exposures to products of combustion.

Recommendation #2: Implement an overall health and safety program such as the one recommended in NFPA 1500, Standard on Fire Department Occupational Safety and Health Program.

NFPA 1500 provides the framework for a safety and health program for fire departments.²² The specified goal of the standard is to reduce the probability of occupational fatalities, illnesses, and disabilities among fire fighters. NFPA points out that the standard is meant to be appropriate for voluntary compliance tailored to the needs of each individual department. Formal implementation of the standard, particularly the development of a written plan for compliance with NFPA 1500, should include development of fire service occupational health programs outlined both in NFPA 1500 and 1582 (discussed below).

Recommendation #3: Providing fire fighters with periodic medical evaluations, including a exercise cardiac stress test for those employees above the age of 40 as recommended by NFPA 1582, Standard of Medical Requirements for Fire Fighters and the IAFF/IAFC Wellness-Fitness Initiative.

As mentioned in the discussion section, the NFPA 1582 currently recommends exercise stress tests for fire fighters above the age of 40

and the IAFF/IAFC Wellness-Fitness Initiative.^{13,14}

Recommendation #4: Initiating a wellness/fitness program to reduce risk factors for cardiovascular disease and improve cardiovascular capacity.

NFPA 1500 requires a wellness program that provides health promotion activities for preventing health problems and enhancing overall well-being. In 1997, the International Association of Fire Fighters and the International Association of Fire Chiefs joined in a comprehensive Fire Service Joint Labor Management Wellness/Fitness Initiative to improve fire fighter quality of life and maintain physical and mental capabilities of fire fighters. Ten fire departments across the United States joined this effort to pool information about their physical fitness programs and to create a practical fire service program. They produced a manual with a video detailing elements of such a program.¹³ These materials should be reviewed by the Fire Department to identify elements that would be feasible and effective in their situation.

Recommendation #5: Fire Departments that wish to utilize the new modalities of testing, Ultra-Fast CT cardiac scanning or Exercise Physiologic Pulmonary function testing, should do so in a controlled manner allowing for evaluation of these tools in this population.

Exercise Pulmonary Function Testing, though expensive, is a well tested modality to directly measure early declines in physical fitness. As such it is a modality that might play an important role for fire fighters between the ages of 20 and 40 as they establish their life-long exercise habits. This is a period during which job demands, family obligations, and other life stresses often reduce the level of exercise that fire fighters secure on a regular basis. As fire



Battalion Chief Dies as a Result of a Heart Attack that Occurred During Training - Illinois

fighting is predominantly a sedentary job with periods of extreme exertion, often in the presence of a carbon monoxide rich atmosphere, such an index might graphically demonstrate the need for continued exercise. This might well have an effect on fire fighters' cardiovascular mortality in their 40s and 50s.

Ultra-Fast CT scanning is a newer modality not fully evaluated designed to detect and follow the development of asymptomatic coronary artery disease. It visualizes the calcium deposited in coronary artery plaques though not the plaque itself. The evidence is not well established as yet as to whether this new testing technique can identify disease missed by the more traditional exercise modalities; it is however suggestive at least in some individuals. A controlled trial amongst fire fighters would be advantageous in evaluating this new test and might provide benefit to the individuals involved.

REFERENCES

1. Myerburg RJ, Castellanos A [1998]. Cardiovascular collapse, cardiac arrest, and sudden cardiac death. Chapter 39. In: Fauci AS, Braunwald E, Isselbacher KJ, et al., eds. Harrison's Principles of Internal Medicine. 14th Edition. New York, NY: McGraw-Hill, 222-225.
2. American Heart Association (AHA) [1998]. AHA Scientific Position, Risk Factors for Coronary Artery Disease, Dallas, Texas.
3. Barnard RJ, Duncan HW [1975]. Heart rate and ECG responses of fire fighters. J Occup Med; 17:247-250.
4. 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.

5. Lemon PW, Hermiston RT [1977]. The human energy cost of fire fighting. J Occup Med; 19:558-562.
6. Gledhill N, Jamnik, VK [1992]. Characterization of the physical demands of firefighting. Can J Spt Sci;17(3):207-213.
7. Willich SN, Lewis M, Lowel H, et al. [1993]. Physical exertion as a trigger of acute myocardial infarction. N Eng J Med 329:1684-90.
8. Mittleman MA, Maclure M, Tofler GH, et al, [1993]. Triggering of acute myocardial infarction by heavy physical exertion. N Eng J Med 329:1677-83.
9. Siscovick DS, Weiss NS, Fletcher RH, Lasky T [1984]. The incidence of primary cardiac arrest during vigorous exercise. N Eng J Med 311:874-7.
10. Tofler GH, Muller JE, Stone PH, et al [1992]. Modifiers of timing and possible triggers of acute myocardial infarction in the Thrombolysis in Myocardial Infarction Phase II (TIMI II) Study Group. J Am Coll Cardiol 20:1049-55.
11. Melius, JM. [1995] Cardiovascular Disease Among Fire Fighters. In: Orris P, Melius J, Duffy R, eds. State of the Art Reviews in Occupational Medicine, Firefighters' Safety and Health, Philadelphia, PA: Hanley & Belfus, Inc. 10(4):821-9
12. Guidotti, TL [1995]. Occupational mortality among firefighters: Assessing the association. J Occup Environ Med; 37:1348-56.
13. International Association of Fire Fighters and the International Association of Fire Chiefs. [1997]. The fire service joint labor management wellness/fitness initiative. International Association of Fire



Battalion Chief Dies as a Result of a Heart Attack that Occurred During Training - Illinois

Fighters, Department of Occupational Health and Safety, Washington DC.

14. National Fire Protection Association [2000]. NFPA 1582, Medical Requirements for Fire Fighters and Information for Fire Department Physicians. NFPA, Quincy MA.

15. Michaelides AP, Psomadaki ZD, Dilaveris PE, et al. [1999]. Improved detection of coronary artery disease by exercise electrocardiography with the use of right precordial leads. *New Eng J Med* 340:340-345.

16. Jones, NL. [1997] *Clinical Exercise Testing*. 4th Ed. Philadelphia, PA: WB Saunders, pp. 72-3, 214-5.

17. Wong, N.D. [1995] Coronary Artery Screening by Electron Beam Computed Tomography. *Circulation*; 92:632-636.

18. Teng W. et al., [1996] Relation of electron beam computed tomography screening for

coronary calcium to cardiovascular risk and disease: a review. *Coronary Artery Disease* 7(5):383-9.

19. White MK, Hodous TK [1987]. Reduced work tolerance associated with wearing protective clothing and respirators. *Am Ind Hyg Assoc J* (48):304-310.

20. White MK, Vercruyssen M, Hodous TK [1989]. Work tolerance and subjective responses to wearing protective clothing and respirators during physical work. *Ergonomics* (32)9:1111-1123.

21. Louhevaara V, Smolander J, Tuomi T, et al. [1985]. Effects of an SCBA on breathing pattern, gas exchange, and heart rate during exercise. *J Occup Med* 27(3):213-216.

22. National Fire Protection Association [1997]. NFPA 1500, Standard on Fire Department Occupational Safety and Health Program. NFPA, Quincy MA.

Battalion Chief Dies as a Result of a Heart Attack that Occurred During Training - Illinois



Photo 1



Photo 2



Photo 3