



Fire Captain Suffers Fatal Heart Attack After Conducting Live Fire Training – Pennsylvania

SUMMARY

On August 9, 2008, a 47-year-old male volunteer Captain led an attack team during live fire training. After finishing the 30-minute interior attack, the Captain rotated to an exterior, standby hose crew position. When the second interior crew finished its 30-minute fire attack exercise, all personnel reported to the rehabilitation (rehab) area. Medical personnel triaged all fire fighters. The Captain mentioned that he was “a little tired” but had no other complaints. Although the Captain’s pulse and respiratory rates were elevated, this was expected from anyone just completing a live fire exercise. After relaxing and drinking some water, the Captain related that he felt better. He left the rehab area, walked to his personal vehicle, and lay down on the grass. A short time later, two students walking nearby thought they heard the Captain snoring. They went over to investigate and heard a gurgling noise. They summoned the rehab emergency medical technician (EMT), instructors, and other students for help. A second ambulance was requested, cardiopulmonary resuscitation (CPR) was begun, and an automated external defibrillator (AED) delivered four shocks. The ambulance arrived, and paramedics began advanced life support. The Captain was transported to the hospital’s emergency department, where CPR and advanced life support treatment continued. Approximately 65 minutes after his collapse, despite CPR and advanced life support, the Captain died. The death certificate, completed by the Coroner, and the autopsy, completed by the Forensic Pathologist, listed “arteriosclerotic

cardiovascular disease” as the cause of death and “stress at the live burn exercises” as the underlying cause. The results of the NIOSH investigation support this determination.

The NIOSH investigator offers the following recommendations to address general safety and health issues. Had these recommended measures been in place prior to the Captain’s collapse, his sudden cardiac death may have been prevented at this time.

- *Provide preplacement and annual medical evaluations to fire fighters consistent with National Fire Protection Association (NFPA) 1582, Standard on Comprehensive Occupational Medical Program for Fire Departments, to determine their medical ability to perform duties without presenting a significant risk to the safety and health of themselves or others.*
- *Ensure fire fighters are cleared for return to duty by a physician knowledgeable about the physical demands of fire fighting, the personal protective equipment used by fire fighters, and the various components of NFPA 1582.*
- *Phase in a comprehensive wellness and fitness program for fire fighters to reduce risk factors for cardiovascular disease and improve cardiovascular capacity.*
- *Provide fire fighters with medical clearance to wear a self-contained breathing*



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apparatus (SCBA) as part of the Fire Department's medical evaluation program.

- *Use a secondary (technological) test to confirm appropriate placement of the endotracheal tube.*
- *Recheck vital signs of fire fighters prior to leaving rehab.*

INTRODUCTION & METHODS

On August 9, 2008, a 47-year-old male volunteer Fire Captain suffered a fatal heart attack after leading a live fire exercise. Despite CPR and advanced life support, the Captain died. NIOSH was notified of this fatality on August 11, 2008, by the U.S. Fire Administration. NIOSH contacted the affected Fire Department on August 18, 2008, to gather additional information, and on September 5, 2008, to initiate the investigation. On September 22, 2008, a safety and occupational health specialist from the NIOSH Fire Fighter Fatality Investigation Team traveled to Pennsylvania to conduct an on-site investigation of the incident.

During the investigation, NIOSH personnel interviewed the following people:

- Fire Chief
- Assistant Chief
- Coordinator of the Public Safety Training Center
- Forensic Pathologist

NIOSH personnel reviewed the following documents:

- Fire Department policies and operating guidelines

- Fire Department training records
- Fire Department annual report for 2007
- Training Center incident report
- Emergency medical service (ambulance) incident report
- Hospital emergency department records
- Death certificate
- Autopsy report
- Primary care provider medical records

RESULTS OF INVESTIGATION

Incident. On August 9, 2008, the Captain (acting as ignition officer), along with a lead instructor, safety officer, rapid intervention team officer, and three assistant instructors lead a live fire exercise expected to last 8 hours. The class, held at the Community College Public Safety Training Center, had 13 students in attendance.

The class began at 0800 hours. Weather conditions included a temperature of 63 degrees Fahrenheit (°F) and 73% relative humidity [NOAA 2008]. The lead instructor gave the safety briefing and discussed the training elements: location of command, fire apparatus, rehab, radio communications, and personal protective equipment; burn building description; crew assignments; accountability; and emergency evacuation in accordance with NFPA 1403, Standard on Live Fire Training Evolutions [NFPA 2007a].

Vital signs were taken for each participant just prior to commencement of the exercises. The Captain's blood pressure reading at 0830 hours was slightly elevated at 148/90 mil-



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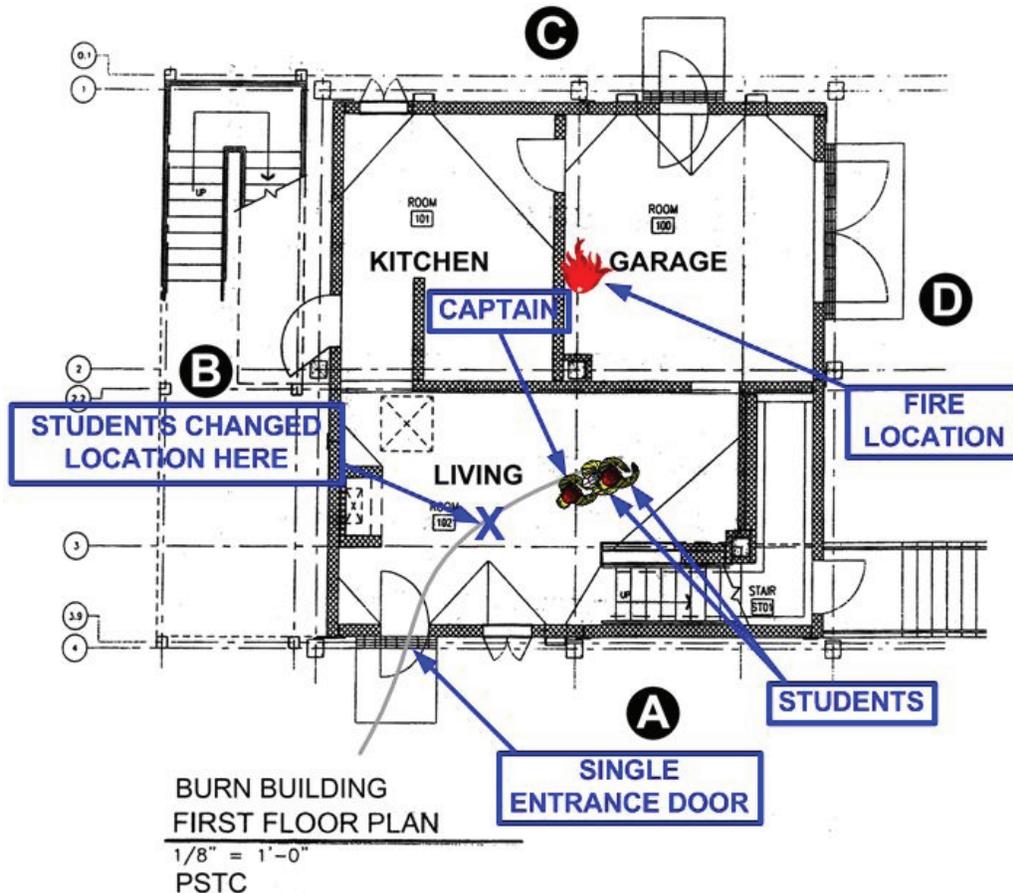
limeters of mercury [mmHg]), but his pulse and respiratory rate were within normal limits. The Captain led the initial attack team of two students (Crew 1) into the Class A (wood incinerating) burn building (see Photograph 1 and Figure 1). Wearing full turnout gear and SCBA (on air), Crew 1 entered the burn building through Side A. During the live fire exercise, the ceiling temperature reached 1000 °F as measured by thermocouples (see Figure 2). The Captain advised the students about tactics on the first floor during the exercise. Crew 1 then advanced a charged 1¾-inch hoseline into the corner of the living room at the entrance to

the garage, where the fire was located. They stopped briefly to observe the smoke conditions, then sprayed a stream high into the fire, then low into the fire. After initial knockdown,

Photo 1



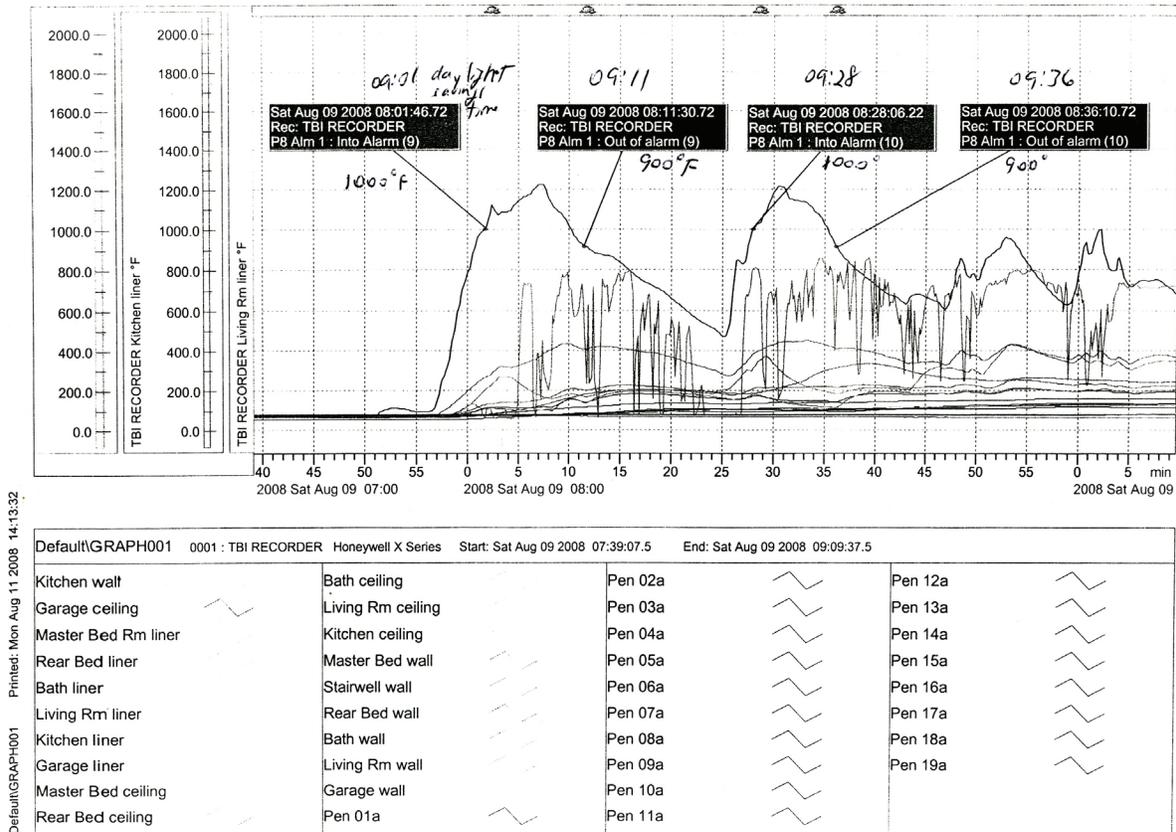
Figure 1





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Figure 2



more fuel was added to the fire for the next burn, and Crew 1 retreated to the living room where the two Crew 1 students changed positions. Crew 1 then advanced the hoseline again, this time entering the garage area and knocking down the fire. Next, the crew hydraulically ventilated out the rear door for approximately 1 minute. Crew 1 then backed the hoseline out the front door. This exercise took approximately 30 minutes.

Crew 1, including the Captain, became the back-up crew during the second evolution. The Captain related how cool the temperature was that day compared to some previous classes with which he had been involved. The weather

conditions at this time (0915 hours) included a temperature of 70°F and 57% relative humidity. After Crew 2 completed the second evolution (also about 30 minutes), an extended break was announced, and personnel reported to rehab, about 100 feet from the burn building. The emergency medical technician in rehab triaged all fire fighters. The Captain stated that he felt “a little tired.” The Captain’s vital signs were taken (at 1025 hours); his readings included a blood pressure of 132/86 (normal is <140/<90) mmHg, 22 respirations per minute (normal is 8-14 breaths per minute), and a pulse rate of 110 beats per minute (normal is 60-100). The EMT advised him to relax near the cool-misting system and drink some water,



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which he did for approximately 5–7 minutes. After a short time, the EMT asked the Captain how he was doing; the Captain replied that he felt better. The Captain then left the rehab area, walked approximately 150 feet to his parked car, and laid down on the grass.

At approximately 1040 hours, two students walking nearby heard a “snoring sound” coming from the Captain, as if he were sleeping. They went over to investigate and heard a “gurgling noise.” The two summoned the rehab EMT for help.

The EMT, several instructors, and students responded to the Captain. 911 was called, and a second ambulance was dispatched. The Captain was assessed and found to be unresponsive, not breathing, and without a pulse. CPR was begun, and the AED was retrieved. Four shocks were administered without a positive change in the Captain’s condition. The ambulance arrived at 1056 hours, and paramedics began advanced life support. A cardiac monitor was placed, revealing asystole. The Captain was successfully intubated on the second attempt, and oxygen administered; tube placement was confirmed by auscultation and visualization. An IV was begun, and cardiac resuscitation medications were administered; he was defibrillated four additional times. He was placed onto a stretcher and loaded into the ambulance, which departed the scene at 1120 hours en route to the hospital’s emergency department. No positive change occurred in the Captain’s condition during transport. The ambulance arrived at the hospital at 1140 hours. Inside the emergency department, advanced life support treatment continued until 1145 hours, when the Captain was pronounced dead by the attending physician.

Medical Findings. The death certificate, completed by the Coroner, and the autopsy, completed by the Forensic Pathologist, listed “arteriosclerotic cardiovascular disease” as the cause of death and “stress at the live burn exercises” as the underlying cause. Findings from the autopsy include an acute thrombosis, severe arteriosclerotic cardiovascular disease, and cardiomegaly. Specific findings from the autopsy report are listed in Appendix A.

The Captain was 75 inches tall and weighed 300 pounds, giving him a body mass index (BMI) of 37.5. A BMI >30.0 kilograms per meters squared (kg/m²) is considered obese [CDC 2008]. The Captain’s risk factors for CAD included male gender, age over 45, high blood cholesterol, and obesity. In 2004, he was diagnosed with hyperlipidemia and was prescribed a lipid-lowering medication. In 2005 and 2006, the Captain was medically cleared by his primary care provider to participate in a physical ability test. Fire Department records did not indicate whether the Captain actually completed a physical ability test. However, he taught the fire fighting essentials class in which the physical ability test was a component. In a 2006 visit to his primary care physician for swollen feet, an ultrasound revealed no evidence of a deep vein thrombosis, an electrocardiogram (EKG) was normal, and an echocardiogram showed normal cardiac size and function. His last visit to his primary care provider was for a sinus infection 7 months before he died. He did not report heart-related symptoms (chest pain, chest pressure, angina, shortness of breath on exertion, etc.) to his physicians, his family, the Fire Department, or the Training Center.



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DESCRIPTION OF THE FIRE DEPARTMENT

At the time of the NIOSH investigation, the volunteer Fire Department consisted of one fire station with 38 uniformed personnel. The department served 1,000 residents in a geographic area of 3.3 square miles.

In 2007, the Fire Department responded to 220 calls: 9 fires, 131 emergency medical calls, 34 motor vehicle accidents, 13 hazardous condition calls, and 35 other calls.

Membership and Training. The Fire Department votes on new fire fighter applicants, who must be at least 18 years of age and have a valid state driver's license. New members must attend the 166-hour fire fighter essentials training course or have prior fire fighter experience. The State has no minimum requirement for fire fighter certification. The Captain was certified as a Fire Fighter II, Fire Officer, Instructor-Suppression Level, Emergency Medical Technician, Hazardous Materials Technician, Vehicle Rescue Technician, and Driver Operator; he had 22 years of fire fighting experience.

Preplacement and Periodic Medical Evaluation. Preplacement and periodic (annual) medical evaluations are not currently required by the Fire Department or the Training Center. An annual SCBA facepiece fit test is required by the Fire Department for interior structural fire fighters. However, SCBA medical clearance is not required. Members injured on duty must be evaluated by their primary care physician, who makes the final determination regarding return to duty.

Health and Wellness Programs. The Fire Department does not have a wellness/fitness program, but exercise (strength only) equipment is available in the fire station. Health maintenance programs are not available from the Town.

DISCUSSION

Cardiovascular Disease. In the United States, atherosclerotic CAD is the most common risk factor for cardiac arrest and sudden cardiac death [Meyerburg and Castellanos 2008]. Risk factors for its development include age over 45, male gender, family history of CAD, high blood pressure, high blood cholesterol, obesity/physical inactivity, and diabetes [AHA 2008]. The Captain had four of these risk factors (age over 45, male gender, high blood cholesterol, and obesity).

The narrowing of the coronary arteries by atherosclerotic plaques occurs over many years, typically decades [Libby 2008]. However, the growth of these plaques probably occurs in a nonlinear, often abrupt fashion [Shah 1997]. 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 [Fuster et al. 1992]. This sudden blockage is primarily due to blood clots (thromboses) forming on top of atherosclerotic plaques. At autopsy, the Captain had an acute thrombus in his left main coronary artery, confirming the diagnosis of a sudden heart attack.

Epidemiologic studies have found that heavy physical exertion sometimes immediately precedes and triggers the onset of acute heart attacks [Siscovick et al. 1984; Tofler et al. 1992;



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Mittleman et al. 1993; Willich et al. 1993]. Heart attacks in fire fighters have been associated with alarm response, fire suppression, and heavy exertion during training (including physical fitness training) [Kales et al. 2003; Kales et al. 2007; NIOSH 2007]. The Captain had led a fire suppression exercise in a burn building while wearing full turnout gear and SCBA. While this activity could be considered light to moderate physical activity [AIHA 1971; Gledhill and Jamnik 1992], it occurred in a burn building with temperatures reaching 1000 °F. Given the Captain's underlying CAD, his heart attack and subsequent sudden cardiac death was probably triggered by the physical stress of the fire suppression exercise, the high heat environment, and the use of full turnout gear and SCBA.

Cardiomegaly/Left Ventricular Hypertrophy.

On autopsy, the Captain was found to have left ventricular hypertrophy (LVH) and an enlarged heart. This finding was not identified during his EKG and echocardiogram in 2006. Both LVH and cardiomegaly increase the risk for sudden cardiac death [Levy et al. 1990]. Hypertrophy of the heart's left ventricle is a relatively common finding among individuals with long-standing high blood pressure, a heart valve problem, or chronic cardiac ischemia (reduced blood supply to the heart muscle) [Siegel 1997]. The Captain did not have high blood pressure or a heart valve problem; therefore, his LVH was probably due to chronic ischemia from his CAD.

Congenital Atrial Septal Defect. At autopsy, a congenital atrial septal defect was identified. Atrial septal defect is one of the most commonly recognized congenital cardiac anomalies. About 1 million Americans are affected [Ther-

rien and Webb 2001]. However, because mild to moderate lesions are typically asymptomatic, the condition is rarely diagnosed [Friedman and Silverman 2001]. Patients with an atrial septal defect typically survive to old age despite being at increased risk for pulmonary hypertension, tricuspid incompetence, atrial fibrillation, paradoxical thromboembolism, or stroke [Rose 2001]. The diagnosis is typically made by echocardiogram.

The Captain had an echocardiogram performed in 2006 which revealed only trace regurgitation.

It is unclear why his atrial septal defect was not picked up during this evaluation.

According to the Forensic Pathologist, the Captain's condition was thought to be of minor clinical significance because he did not have shortness of breath upon exertion and, on autopsy, he had normal cardiac chambers, no evidence of pulmonary hypertension, and no right ventricular hypertrophy.

Carbon Monoxide, Carboxyhemoglobin Levels, and Carbon Monoxide Poisoning. Carbon monoxide (CO) is a component of fire smoke.

When inhaled, CO crosses the alveolar (lung) membrane and binds to hemoglobin, forming carboxyhemoglobin (COHb). The COHb reduces the availability of oxygen to other tissues and disrupts the intercellular use of oxygen which can lead to hypoxia (inadequate oxygen supply) [Alonso et al. 2003]. The brain and the heart are the organs most vulnerable to hypoxia. Symptoms/signs associated with CO poisoning include headache, dizziness, weakness, nausea, confusion, fast heart rate, and shortness of breath [Ernst and Zibrak 1998].



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Upon entering rehab, the Captain had a fast heart rate and shortness of breath which were attributed to physical exertion during the live fire training, a reasonable attribution given the physical demands of the live fire evolution.

COHb levels in the blood are used to assess CO exposure and CO poisoning. COHb levels, however, do not correlate well with clinical findings and profound unconsciousness has been reported with levels less than 20% [Kindwall 1994; Piantadosi 2002]. CO levels in non-smokers are typically less than 3.0% [Ernst and Zibrak 1998]. At autopsy, the Captain's COHb level was 9%. This level is higher than normal for a non-smoker, but not at a level considered dangerous [Piantadosi 2002]. Resuscitation efforts (intubation and administration of 100% oxygen for 55 minutes) would be expected to accelerate the elimination of COHb and lower COHb level [Ernst and Zibrak 1998; Alonso et al. 2003]. But the Captain never regained a heart beat, therefore these resuscitations measures are thought to have had minimal impact on his COHb level.

There is some evidence that prolonged exposure to low levels of CO may have adverse health effects, particularly cardiovascular. The adverse cardiovascular consequences reported at COHb levels of 2–5% include a decrease in exercise tolerance among healthy individuals and those with ischemic heart disease [Aronow and Cassidy 1975; Allred et al. 1989; Kleinman et al. 1989]. It has also been suggested that increased levels of CO might contribute to the development of coronary heart disease [Wald et al. 1973; Borland et al. 1983], possibly through effects on

platelet and endothelial functioning [Thom and Ischiropoulos 1997], though this is speculative [Mennear 1993].

In summary, the Captain was exposed to carbon monoxide at some point during his live fire exercise and for an undetermined time; this probably caused the elevation of his COHb level. It is not clear what role, if any, this exposure had in triggering his heart attack and sudden cardiac death.

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, Standard on Comprehensive Occupational Medical Program for Fire Departments [NFPA 2007b]. This voluntary industry standard provides the components of a preplacement and annual medical evaluation, and medical fitness for duty criteria. This standard recommends an exercise stress test performed “as clinically indicated by history or symptoms” and refers the reader to Appendix A [NFPA 2007b]. Items in the Appendix A are not standard requirements, but are provided for “informational purposes only.” Appendix A recommends that sub-maximal (85% of predicted heart rate) stress tests be used as a screening tool to evaluate a fire fighter's aerobic capacity. Maximal (e.g., symptom limiting) stress tests with imaging should be use for fire fighters with:

- abnormal screening sub-maximal tests
- cardiac symptoms
- known coronary artery disease
- males over the age of 45 and females over the age of 55 with two or more risk



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factors for coronary artery disease. Risk factors are defined as hypercholesterolemia (total cholesterol greater than 240 mg/dL), hypertension (diastolic blood pressure greater than 90 mm Hg), smoking, diabetes mellitus, or family history of premature coronary artery disease (heart attack or sudden cardiac death in a first-degree relative less than 60 years old).

The American College of Cardiology / American Heart Association (ACC/AHA) has also published exercise testing guidelines [Gibbons et al. 2002]. The ACC/AHA guideline states that the evidence to conduct stress tests in asymptomatic individuals with diabetes mellitus is “Class IIa” which is defined as “conflicting evidence and/or a divergence of opinion about the usefulness/efficacy but the weight of the evidence/opinion is in favor.” The ACC/AHA guideline says the evidence is “less well established” (Class IIb) for the following groups:

1. Evaluation of persons with multiple risk factors as a guide to risk-reduction therapy with the risk factors essentially the same as the NFPA listed above.
2. Evaluation of asymptomatic men older than 45 years, and women older than 55 years:
 - Who are sedentary and plan to start vigorous exercise
 - Who are involved in occupations in which impairment might jeopardize public safety [e.g., fire fighters]

- Who are at high risk for coronary artery disease due to other diseases (e.g., peripheral vascular disease and chronic renal failure)

The U.S. Department of Transportation (DOT) has also provided guidance for those seeking medical certification for a commercial drivers license. An expert medical panel recommended exercise tolerance tests for asymptomatic “high risk” drivers [Blumenthal 2007]. The panel defines high risk drivers as those with any of the following:

- Diabetes mellitus
- Peripheral vascular disease
- Person above the age of 45 with multiple risk factors for coronary heart disease
- Framingham risk score predicting a 20% coronary heart disease event risk over the next 10 years

The U.S. Preventive Services Task Force (USPSTF) does not recommend stress tests for asymptomatic individuals at low risk for coronary heart disease events. For individuals at increased risk for coronary heart disease events, the USPSTF found “insufficient evident to recommend for or against routine screening with EKG, exercise tolerance test, or electron beam computerized tomography scanning...” Rather, they recommend the diagnosis and treatment of modifiable risk factors (hypertension, high cholesterol, smoking, and diabetes) [USPSTF 2004]. The USPSTF does note that “For people in certain occupations, such as pilots, and heavy equipment operators (for whom sudden incapacitation or sudden death may endanger the safety of others), consideration other than the health benefit



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to the individual patient may influence the decision to screen for coronary heart disease.”

According to NFPA, the ACC/AHA, and the U.S. DOT, the Captain should have had a stress test. The Captain’s underlying CAD could have been identified, and he probably would have been referred for further evaluation and treatment.

Physical Fitness Programs for Structural Fire Fighters. NFPA 1583, Standard on Health-Related Fitness Programs for Fire Department Members, establishes the minimum requirements for the development of a health-related fitness and exercise program and health promotion for fire department members involved in emergency operations [NFPA 2008a]. Members must be cleared annually for participation in a fitness assessment by the fire department physician and are required to participate in a periodic fitness assessment under the supervision of the fire department health and fitness coordinator [NFPA 2008a]. The fitness assessment includes 1) aerobic capacity, 2) body composition, 3) muscular strength, 4) muscular endurance, and 5) flexibility. The exercise and fitness program includes 1) education, 2) individualized participation, 3) warm-up and cool-down exercise guidelines, 4) aerobic exercise, 5) muscular strength and endurance, 6) flexibility exercise, 7) healthy back exercise, and 8) safety and injury prevention [NFPA 2008a].

NFPA 1500, Standard on Fire Department Occupational Safety and Health Program, requires the fire department to develop physical performance requirements for candidates and members who engage in emergency operations [NFPA 2007c]. Members who engage in emergency operations must be annually qualified

(physical ability test) as meeting these physical performance standards [NFPA 2007c].

The National Volunteer Fire Council (NVFC) and the U.S. Fire Administration (USFA)’s Health and Wellness Project Health and Wellness Guide was developed to improve health and wellness within the volunteer fire service [USFA 2004]. This guide provides suggestions for successfully implementing a health and wellness program for volunteer fire departments.

Rehab Standards for Structural Fire Fighters. NFPA 1584, Standard on the Rehabilitation Process for Members During Emergency Operations and Training Exercises, establishes criteria for developing and implementing a rehab process for fire department members at incident scene operations and training operations [NFPA 2008b]. The Training Center should be commended for setting up and maintaining a rehab unit in compliance with NFPA 1584.

Live Fire Training Standards for Structural Fire Fighters. NFPA 1403, Standard on Live Fire Training Evolutions, contains requirements for training fire suppression personnel under live fire conditions [NFPA 2007a]. The Training Center should be commended for setting up and running a live fire training session consistent with NFPA 1403. A basic life support ambulance and emergency medical technician assistance was on site.

RECOMMENDATIONS

The NIOSH investigator offers the following recommendations to address general safety and health issues. Had these recommended measures been in place prior to the Captain’s col-



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lapse, his sudden cardiac death may have been prevented at this time.

Recommendation #1: Provide preplacement and annual medical evaluations to fire fighters consistent with National Fire Protection Association (NFPA) 1582, Standard on Comprehensive Occupational Medical Program for Fire Departments, to determine their medical ability to perform duties without presenting a significant risk to the safety and health of themselves or others.

Guidance regarding the content and frequency of these evaluations can be found in NFPA 1582 and in the International Association of Fire Fighters (IAFF)/International Association of Fire Chiefs (IAFC) Fire Service Joint Labor Management Wellness/Fitness Initiative [IAFF, IAFC 2000; NFPA 2007b]. However, the Fire Department and the Training Center are not legally required to follow this standard or this initiative. Applying this recommendation involves economic repercussions and may be particularly difficult for small volunteer fire departments to implement. NFPA 1500, Standard on Fire Department Occupational Safety and Health Program, paragraphs A.10.6.4 and A.11.1.1 and the National Volunteer Fire Council (NVFC) Health and Wellness Guide address these issues [USFA 2004; NFPA 2007c].

To overcome the financial obstacle of medical evaluations, the Fire Department could urge current members to get annual medical clearances from their private physicians. Another option is having the annual medical evaluations completed by paramedics and emergency medical technicians (EMTs) from the local EMS (vital signs, height, weight, visual acuity, and electrocardiogram [EKG]). This information

could then be provided to a community physician (perhaps volunteering his or her time), who could review the data and provide medical clearance (or further evaluation, if needed). The more extensive portions of the medical evaluations could be performed by a private physician at the fire fighter's expense (personal or through insurance), provided by a physician volunteer, or paid for by the Fire Department, City, or State. Sharing the financial responsibility for these evaluations between fire fighters, the Fire Department, the City, the State, and physician volunteers may reduce the negative financial impact on recruiting and retaining needed fire fighters.

Recommendation #2: Ensure that fire fighters are cleared for return to duty by a physician knowledgeable about the physical demands of fire fighting, the personal protective equipment used by fire fighters, and the various components of NFPA 1582.

Guidance regarding medical evaluations and examinations for structural fire fighters can be found in NFPA 1582 [NFPA 2007b] and in the IAFF/IAFC Fire Service Joint Labor Management Wellness/Fitness Initiative [IAFF, IAFC 2000]. According to these guidelines, the Fire Department should have an officially designated physician who is responsible for guiding, directing, and advising the members with regard to their health, fitness, and suitability for duty as required by NFPA 1500, Standard on Fire Department Occupational Safety and Health Program [NFPA 2007c]. The physician should review job descriptions and essential job tasks required for all Fire Department positions and ranks in order to understand the physiological and psychological demands of fire fighters and the environmental conditions under which they



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must perform, as well as the personal protective equipment they must wear during various types of emergency operations.

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

Guidance for fire department wellness/fitness programs is found in NFPA 1583, Standard on Health-Related Fitness Programs for Fire Fighters, and the IAFF/IAFC Fire Service Joint Labor Management Wellness/Fitness Initiative [IAFF, IAFC 2000; NFPA 2008a]. Worksite health promotion programs have been shown to be cost effective by increasing productivity, reducing absenteeism, and reducing the number of work-related injuries and lost work days [Stein et al. 2000; Aldana 2001]. Fire service health promotion programs have been shown to reduce CAD risk factors and improve fitness levels, with mandatory programs showing the most benefit [Dempsey et al. 2002; Womack et al. 2005; Blevins et al. 2006]. A recent study conducted by the Oregon Health and Science University reported a savings of more than \$1 million for each of four large fire departments implementing the IAFF/IAFC wellness/fitness program compared to four large fire departments not implementing a program. These savings were primarily due to a reduction of occupational injury/illness claims with additional savings expected from reduced future nonoccupational healthcare costs [Kuehl 2007].

Recommendation #4: Provide fire fighters with medical clearance to wear SCBA as part of the Fire Department's medical evaluation program.

The Occupational Safety and Health Administration (OSHA) Revised Respiratory Protection Standard requires employers to provide medical evaluations and clearance for employees using respiratory protection [29 CFR 1910.134]. These clearance evaluations are required for private industry employees and public employees in States operating OSHA-approved State plans. Pennsylvania does not operate an OSHA-approved State plan; therefore, public sector employers (including volunteer/paid fire departments) are not required to comply with OSHA standards. Nonetheless, NIOSH investigators recommend voluntary compliance with this OSHA standard.

Recommendation #5: Use a secondary (technological) test to confirm appropriate placement of the endotracheal tube.

To reduce the risk of improper intubation, the American Heart Association and the International Liaison Committee on Resuscitation published recommendations in the Guidelines 2000 for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care [AHA 2000]. These guidelines recommend confirming tube placement by primary and secondary methods. Primary confirmation is the five-point auscultation: left and right anterior chest, left and right midaxillary, and over the stomach. Secondary confirmation requires a technology test, either an end-tidal carbon dioxide detector or an esophageal detector device. In this incident, the Captain had bilateral breath sounds confirmed by auscultation and chest rise; however, secondary confirmation was not performed. This recommendation does not imply that the endotracheal tube was misplaced or that it contributed to the Captain's death. We raise this issue only to ensure that future advanced life support resuscitation efforts follow AHA guidelines.



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Recommendation #6: Recheck vital signs of fire fighters prior to leaving rehab.

While not specifically required by NFPA 1584, fire fighter's vital signs should be rechecked prior to leaving rehab to ensure there is no medical condition to preclude the fire fighter from participating in further activities. Upon exiting rehab, the fire fighter should be directed to the rest and refreshment unit or to the medical evaluation/treatment unit [USFA 2008].

¹Code of Federal Regulations. See CFR in references.

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INVESTIGATOR INFORMATION

This incident was investigated by the NIOSH Fire Fighter Fatality Investigation and Prevention Program, Cardiovascular Disease Component located in Cincinnati, Ohio. Mr. Tommy Baldwin (M.S.) led the investigation and co-authored the report. Mr. Baldwin is a Safety and Occupational Health Specialist, a National Association of Fire Investigators (NAFI) Certified Fire and Explosion Investigator, an International Fire Service Accreditation Congress (IFSAC) Certified Fire Officer I, and a former Fire Chief and Emergency Medical Technician. Dr. Thomas Hales (M.D., M.P.H.) provided medical consultation and co-authored the report. Dr. Hales is a member of the NFPA Technical Committee on Occupational Safety and Health, and Vice-Chair of the Public Safety Medicine Section of the American College of Occupational and Environmental Medicine (ACOEM).



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Appendix A: Autopsy Findings

- Coronary artery disease
- Cardiomegaly (enlarged heart)(heart weighed 500 grams [g]; predicted normal weight is 456 g (ranges between 346 g and 602 g as a function of gender, age, and body weight) [Silver and Silver 2001]
- Atherosclerotic CVD
 - Thrombus (blood clot) in the main left coronary artery causing total occlusion
 - Severe (75%–80%) focal narrowing of the left anterior descending coronary artery
 - Minimal (10%–15%) focal narrowing of the right coronary artery
 - No focal narrowing of the left circumflex coronary artery
 - No areas of scarring in the right ventricular myocardium
- Left ventricular hypertrophy
 - Left ventricle and interventricular septum walls thickened (1.6 centimeters [cm], 2.0 cm respectively)
 - Normal at autopsy is 0.76–0.88 cm [Colucci and Braunwald 1997]
 - Normal by echocardiographic measurement is 0.6–1.1 cm) [Armstrong and Feigenbaum 2001]
- Wide congenital atrial septal defect
- Normal cardiac valves
- No evidence of a pulmonary embolus

(blood clot in the lung arteries)

- Blood tests for volatiles (ethanol, acetaldehyde, 1-propanol, 2-propanol, and acetone) and cyanide were negative
- Blood test for carbon monoxide revealed a carboxyhemoglobin level of 9% (toxic level is 15%–35% saturation [Winek 1976])

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The National Institute for Occupational Safety and Health (NIOSH), an institute within the Centers for Disease Control and Prevention (CDC), is the federal agency responsible for conducting research and making recommendations for the prevention of work-related injury and illness. In fiscal year 1998, the Congress appropriated funds to NIOSH to conduct a fire fighter initiative. NIOSH initiated the Fire Fighter Fatality Investigation and Prevention Program to examine deaths of fire fighters in the line of duty so that fire departments, fire fighters, fire service organizations, safety experts and researchers could learn from these incidents. The primary goal of these investigations is for NIOSH to make recommendations to prevent similar occurrences. These NIOSH investigations are intended to reduce or prevent future fire fighter deaths and are completely separate from the rulemaking, enforcement and inspection activities of any other federal or state agency. Under its program, NIOSH investigators interview persons with knowledge of the incident and review available records to develop a description of the conditions and circumstances leading to the deaths in order to provide a context for the agency's recommendations. The NIOSH summary of these conditions and circumstances in its reports is not intended as a legal statement of facts. This summary, as well as the conclusions and recommendations made by NIOSH, should not be used for the purpose of litigation or the adjudication of any claim. For further information, visit the program website at

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