



Fire Chief Suffers Heart Attack While Fighting a Structure Fire and Dies – Mississippi

Executive Summary

On March 4, 2012, a 45-year-old male volunteer fire chief (“the Chief”) was dispatched to a residential structure fire. At the scene, the Chief assisted in exterior fire suppression operations for about 30 minutes. Smoke exposure was intermittent, and the Chief did not wear self-contained breathing apparatus (SCBA). The Chief and a crew member suddenly began coughing, became nauseated, and vomited. They took a rest break to drink some water, but both remained nauseated and became dizzy. The on-scene deputy police chief transported both to the hospital’s emergency department (ED), where the Chief began complaining of chest pain; an acute heart attack was diagnosed. Despite care in the ED for approximately 75 minutes, the Chief suffered a cardiac arrest and died. Neither the ED nor the medical examiner’s office measured carboxyhemoglobin levels to assess carbon monoxide exposure or possible carbon monoxide poisoning. The other crew member was treated for heat illness and released with no complications.

The death certificate, completed by the county medical examiner investigator, listed “myocardial infarction” as the cause of death. The autopsy report, completed by the state deputy chief medical examiner, listed “atherosclerotic and hypertensive heart disease” as the cause of death. Given the Chief’s long history of underlying coronary heart disease, NIOSH investigators concluded that the physical stress of fire suppression activities triggered his heart attack and subsequent cardiac death.

NIOSH investigators offer the following recommendations to address safety and health issues and prevent similar incidents in the future.

Measure carboxyhemoglobin levels on symptomatic or unresponsive fire fighters exposed to fire smoke.

Provide preplacement and annual medical evaluations to all fire fighters consistent with NFPA 1582, Standard on Comprehensive Occupational Medical Program for Fire Departments.

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.

Phase in a mandatory comprehensive wellness and fitness program for fire fighters.

Perform an annual physical performance (physical ability) evaluation for all members.

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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 1998, Congress appropriated funds to NIOSH to conduct a fire fighter initiative that resulted in the NIOSH “Fire Fighter Fatality Investigation and Prevention Program” which examines line-of-duty-deaths or on duty deaths of fire fighters to assist fire departments, fire fighters, the fire service and others to prevent similar fire fighter deaths in the future. The agency does not enforce compliance with State or Federal occupational safety and health standards and does not determine fault or assign blame. Participation of fire departments and individuals in NIOSH investigations is voluntary. Under its program, NIOSH investigators interview persons with knowledge of the incident who agree to be interviewed and review available records to develop a description of the conditions and circumstances leading to the death(s). Interviewees are not asked to sign sworn statements and interviews are not recorded. The agency’s reports do not name the victim, the fire department or those interviewed. The NIOSH report’s summary of the conditions and circumstances surrounding the fatality is intended to provide context to the agency’s recommendations and is not intended to be definitive for purposes of determining any claim or benefit. For further information, visit the program website at www.cdc.gov/niosh/fire or call toll free 1-800-CDC-INFO (1-800-232-4636).

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Introduction & Methods

On March 4, 2012, a 45-year-old male volunteer fire chief suffered symptoms consistent with angina while fighting a structure fire. Shortly thereafter he suffered a heart attack and subsequent cardiac arrest in the local hospital's ED. Cardiac resuscitation efforts were unsuccessful. NIOSH contacted the affected fire department (FD) on March 6, 2012, to gather additional information, and on March 30, 2012, to initiate the investigation. On April 11, 2012, a safety and occupational health specialist from the NIOSH Fire Fighter Fatality Prevention and Investigation Program conducted an on-site investigation of the incident.

During the investigation, NIOSH personnel interviewed the following people:

- Fire chief (current)
- Assistant fire chief
- FD captain
- Police chief
- Deputy police chief
- Ambulance service personnel
- Deceased fire chief's spouse

NIOSH personnel reviewed the following documents:

- FD standard operating procedures
- FD incident report
- Hospital ED records
- Death certificate
- Autopsy report
- Primary care physician records

Investigative Results

Incident. On March 4, 2012, the FD was dispatched to a fire in a two-story residential dwelling at 0318 hours. Seven FD personnel, including the Chief, responded directly to the scene. Engine 1, staffed by two FD personnel, arrived on-scene at 0340 hours to find a two-story, wood-framed residence fully involved in fire and heavy smoke conditions. One neighboring structure was approximately 30 feet away, and two motor vehicles were parked approximately 20 feet away. Weather conditions included a temperature of 42 degrees Fahrenheit and 70% relative humidity [NOAA 2012].

Fire fighters wearing full turnout gear without SCBA pulled a 2½-inch hoseline, and the Chief and a crew member applied water to the exterior of the burning dwelling and neighboring structures. At about 0415 hours the Chief and crew member smelled an odor, and both vomited. As other FD personnel continued with the exterior fire suppression, the Chief and crew member rested and drank some water. Both were experiencing nausea and dizziness. The deputy police chief who was on scene notified dispatch and requested an ambulance at 0419, but their condition worsened. At 0420 hours the deputy police chief transported them directly to the hospital's ED in his vehicle.

Inside the ED, the Chief complained of non-radiating chest pain. Initially the Chief had normal blood pressure (124/62 millimeters of mercury [mmHg]) and pulse (74 beats per minute). However, his respiratory rate was elevated at 24 breaths per minute (normal is 12–16 breaths per minute). An electrocardiogram (EKG) revealed ST-segment elevations in the precordial leads suggesting an acute heart attack (myocardial infarction). The ED staff began treatment for a heart attack including sublingual nitroglycerin (which provided some relief), oxygen,

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Investigative Results (cont.)

aspirin, morphine, metoprolol, and tenecteplase (TNKase) protocol [Melandri et al. 2009].

At 0500 hours, the Chief's blood pressure dropped to 98/57 mmHg, and at 0546 hours he collapsed. The cardiac monitor revealed ventricular fibrillation. Initial cardioversion (shock) successfully restored a heartbeat; however, his heart rhythm reverted to ventricular fibrillation. He was intubated, and cardiac resuscitation medications were administered via intravenous line as nine cardioversions were attempted over 30 minutes. Eventually, the Chief had no heart rhythm (asystole). At 0620 hours, resuscitation efforts were stopped, and the Chief was pronounced dead.

Medical Findings. The death certificate, completed by the county medical examiner investigator, listed "myocardial infarction" as the cause of death. The autopsy report, completed by the state deputy chief medical examiner, listed "atherosclerotic and hypertensive heart disease" as the cause of death. Autopsy findings showed moderate to severe coronary artery disease (CAD) with evidence of a remote (old) heart attack and previous stents placed in his coronary arteries. Other pertinent findings from the autopsy are listed in Appendix A.

The Chief was 67 inches tall and weighed 311 pounds, giving him a body mass index of 48.7 kilograms per meters squared. A body mass index > 30.0 kilograms per meter squared is considered obese [CDC 2011]. The Chief was diagnosed with deep vein thrombosis in 1990, high blood cholesterol in 1993, and hypertension in 2000. In 2007 the Chief suffered a relatively "small" heart attack (inferior wall myocardial infarction) for which he received two stents in his right coronary artery. A subsequent cardiologist stress test showed no perfu-

sion defects, a left ventricular ejection fraction of 48%, and satisfactory wall motion. In 2010, the Chief was hospitalized for severe substernal chest pain. A cardiac catheterization showed a dilated left ventricle with a left ventricular ejection fraction of 40% and minimal CAD. His medications were adjusted and his symptoms resolved, but no job restrictions were considered. At the time of his death the Chief's medications included a blood pressure-lowering medication, a lipid lowering medication, and gout medication.

The Chief was a truck driver and passed the Department of Transportation medical evaluations every 2 years to maintain his commercial driver's license.

Description of the Fire Department

At the time of the NIOSH investigation, the FD consisted of one fire station with 10 volunteer uniformed personnel. It served 4,000 residents in a geographic area of 252 square miles.

Membership and Training. The FD requires new fire fighter applicants to be 18 years of age, have a valid state driver's license, and be voted on by the membership. The new member must attend 5 hours training per month plus one monthly meeting. The Chief was certified as a driver/operator and a confined space rescuer. He had 25 years of fire fighting experience, the last 5 years serving as fire chief.

Preplacement and Annual Medical Evaluations. No preplacement or annual medical evaluation is required. An annual self-contained breathing apparatus facepiece fit test is required. Members injured on duty must be evaluated by the workers' compensation physician who forwards his or her

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Description of the FD (cont.)

determination for return to duty to the FD. Members who are ill and are off duty for 2 or more months must be cleared for return to work by their primary care physician.

Health and Wellness Programs. The FD does not have a wellness/fitness program, and no exercise equipment is available in the fire station. No annual physical ability test is required. The Chief did not participate in an exercise program.

Discussion

Atherosclerotic Coronary Heart Disease. In the United States, atherosclerotic coronary heart disease (CHD) is the most common risk factor for cardiac arrest and sudden cardiac death [Meyersburg and Castellanos 2008]. Risk factors for its development include three non-modifiable factors (age older than 45, male gender, and family history of CHD) and five modifiable factors (smoking, high blood pressure, high blood cholesterol, obesity/physical inactivity, and diabetes) [NHLBI 2011; AHA 2012]. The Chief had known CHD with a previous heart attack with stent placement. He had three of five modifiable CHD risk factors (high blood pressure, high blood cholesterol, obesity/physical inactivity) at the time of his first heart attack and at the time of his death.

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

Discussion (cont.)

is primarily due to blood clots (thromboses) forming on top of atherosclerotic plaques. Establishing a recent (acute) heart attack requires any of the following: characteristic EKG changes, elevated cardiac enzymes, or coronary artery thrombus. In this case, an EKG revealed characteristic changes confirming an acute heart attack (myocardial infarction).

Epidemiologic studies have found that heavy physical exertion sometimes immediately precedes and triggers the onset of acute heart attacks and sudden cardiac death [Albert et al. 2000]. 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 Chief had responded to the alarm and performed exterior fire fighting activities while wearing full turnout gear (no SCBA). These activities expended about 9 METs, which is considered moderate physical activity [Gledhill and Jamnik 1992; Ainsworth et al. 2011].

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 2007a]. This voluntary industry standard provides the components of a preplacement and annual medical evaluation and medical fitness for duty criteria. The Chief had two known conditions relevant to medical clearance: coronary heart disease and heart failure.

Coronary Heart Disease. The Chief had CHD as evidenced by his prior heart attack. He had been

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Discussion (cont.)

unable to reduce or eliminate his three modifiable CHD risk factors. According to NFPA 1582, members with CAD should be precluded from unrestricted fire fighting because of the risk of sudden incapacitation. NFPA 1582 does, however, allow fire fighters with CHD to return to unrestricted duty if certain medical criteria are met [NFPA 2007a]. The criteria include the following:

- (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 of oxygen per minute per kilogram 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 myocardial infarction, angina, or coronary artery disease with persistence of modifiable risk factor(s) for acute coronary plaque rupture (e.g., tobacco use, hypertension despite treatment or hypercholesterolemia with cholesterol ≥ 180 or low density lipoproteins ≥ 100 despite treatment, or glycosylated hemoglobin > 7 despite exercise and/or weight reduction)

The Chief did not meet these criteria.

Left Ventricular Hypertrophy/Cardiomegaly. In the hospital during the second cardiac catheterization (2010), the Chief was found to have a dilated left ventricle with a reduced left ventricular ejection fraction (40%). The autopsy also revealed left ventricular hypertrophy and cardiomegaly, conditions that independently increase the risk of sudden cardiac death [Levy et al. 1990]. Hypertrophy of the heart's left ventricle and cardiomegaly are relatively common findings among individuals with long-standing high blood pressure (hypertension), a heart valve problem, or chronic cardiac ischemia (reduced blood supply to the heart muscle) [Siegel 1997]. The Chief had a history of hypertension and cardiac ischemia. Both conditions could have been responsible for his left ventricular hypertrophy and cardiomegaly.

Heart Failure. According to NFPA 1582, congestive heart failure from any cause including any disease leading to a lower than normal left or right ventricular ejection fraction, even if corrected by medication, compromises the member's ability to safely perform fire fighting tasks and leads to restricted duty [NFPA 2007a]. The Chief's 2010 diagnosis of a dilated left ventricle with a reduced left ventricular ejection fraction should have led to restricted duty.

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Recommendations

NIOSH investigators offer the following recommendations to address safety and health issues and prevent similar incidents in the future.

Recommendation #1: Measure carboxyhemoglobin levels on symptomatic or unresponsive fire fighters exposed to fire smoke.

The hospital involved in the Chief's emergency care did not measure a carboxyhemoglobin (COHb) level. COHb is a blood test used to estimate an individual's exposure to carbon monoxide. Fire smoke contains varying amounts of carbon monoxide and can cause carbon monoxide poisoning, which, in severe cases, can cause sudden death. The Chief was unlikely to have carbon monoxide poisoning from his relatively brief exposure to light fire smoke outside the structure. Furthermore, even if his COHb level was elevated, this would not have affected his treatment or outcome because he was already receiving 100% oxygen therapy via respirator. Nonetheless, we recommend measuring COHb levels in all fire-related deaths to rule out carbon monoxide poisoning.

Recommendation #2: Provide preplacement and annual medical evaluations to all fire fighters consistent with NFPA 1582, Standard on Comprehensive Occupational Medical Program for Fire Departments.

Guidance regarding the content and frequency of these medical 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 [NFPA 2007a; IAFF, IAFC 2008]. These evaluations are performed to determine fire fighters' medical ability to perform duties without presenting a significant risk to the

safety and health of themselves or others. To ensure improved health and safety of candidates and members, and to ensure continuity of medical evaluations, it is recommended the FD comply with this recommendation, particularly the section addressing CHD issues. However, the FD is not legally required to follow the NFPA standard or the IAFF/IAFC initiative. Applying this recommendation involves economic repercussions and may be particularly difficult for smaller fire departments to implement.

To overcome the financial obstacle of medical evaluations, the FD 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 from the local ambulance service (vital signs, height, weight, visual acuity, and 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 FD, city, or state. Sharing the financial responsibility for these evaluations between fire fighters, the FD, the city, the state, and physician volunteers may reduce the negative financial impact on recruiting and retaining needed fire fighters.

Recommendation #3: 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.

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Recommendations (cont.)

Guidance regarding medical evaluations and examinations for structural fire fighters can be found in NFPA 1582 and in the IAFF/IAFC Fire Service Joint Labor Management Wellness/Fitness Initiative [NFPA 2007a; IAFF, IAFC 2008]. According to these guidelines, the FD 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. The physician should review job descriptions and essential job tasks required for all FD positions and ranks to understand the physiological and psychological demands of fire fighters and the environmental conditions under which they must perform, as well as the personal protective equipment they must wear during various types of emergency operations. The FD currently utilizes a workers' compensation physician to clear fire fighters injured on duty and a member's personal physician to clear fire fighters who miss 2 or more months due to illness. The extent of these physicians' knowledge of the fire fighting duties or NFPA 1582 is unknown. The Chief had two cardiac conditions (CHD and heart failure) that should have precluded him from unrestricted duty [NFPA 2007a].

Recommendation #4: Phase in a mandatory comprehensive wellness and fitness program for fire fighters.

Guidance for fire department wellness/fitness programs to reduce risk factors for cardiovascular disease and improve cardiovascular capacity is found in NFPA 1583, Standard on Health-Related Fitness Programs for Fire Fighters, the IAFF/IAFC Fire Service Joint Labor Management Wellness/Fitness Initiative, the National Volunteer Fire Council Health and Wellness Guide, and in Firefighter Fitness: A Health and Wellness Guide [USFA 2004; IAFF, IAFC 2008; NFPA 2008; Schneider 2010]. 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 CHD 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 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]. The FD does not have a wellness/fitness program. Given the FD's structure, the National Volunteer Fire Council program would be very helpful [USFA 2004]. NIOSH recommends a formal, mandatory wellness/fitness program to ensure all members receive the benefits of a health promotion program.

Recommendation #5: Perform an annual physical performance (physical ability) evaluation for all members.

NFPA 1500, Standard on Fire Department Occupational Safety and Health Program, requires the FD to develop physical performance requirements for candidates and members who engage in emergency operations [NFPA 2007b]. Members who engage in emergency operations must be annually qualified (physical ability test) as meeting these physical performance standards for structural fire fighters [NFPA 2007b]. This could be incorporated into the annual task-level training program.

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Investigator Information

This incident was investigated by the NIOSH Fire Fighter Fatality Investigation and Prevention Program, Cardiovascular Disease Component in Cincinnati, Ohio. Mr. Tommy Baldwin (MS) 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 (MD, MPH) 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

- Hypertensive heart disease
 - Cardiomegaly (enlarged heart; heart weighed 660 grams [g]; predicted normal weight is 463 g [ranges between 351 g and 611 g as a function of sex, age, and body weight]) [Silver and Silver 2001]
 - Left ventricular hypertrophy
 - Left ventricle thickened (2.2 centimeter [cm])
 - Normal at autopsy is 0.76–0.88 cm [Colucci and Braunwald 1997]
 - Normal by echocardiographic measurement is 0.6–1.0 cm [Connolly and Oh 2012]
- Coronary artery atherosclerosis
 - Moderate to severe (>75%) focal narrowing of the right coronary artery
 - Moderate focal narrowing of the left anterior descending coronary artery
 - Moderate focal narrowing of the circumflex coronary artery
 - Fibrous scar in the posterior aspect of the left ventricle (old heart attack)
 - Previous stents (two) placed in the right coronary artery
 - No evidence of a coronary artery thrombus (blood clot)
- Normal cardiac valves
- No evidence of a pulmonary embolus (blood clot in the lung arteries)

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