



## Fire Chief Suffers Fatal Heart Attack While Responding to a Structure Fire – Pennsylvania

### SUMMARY

On September 12, 2007, a 56-year-old male volunteer Fire Chief was awakened at his residence at approximately 0100 hours by a civilian notifying him of a fire in a nearby structure. The Chief exited his house and verified the information. The Chief reentered his home to retrieve his portable radio when he collapsed. The Chief's daughter came downstairs, saw her father had collapsed, and ran outside to summon help from the responding fire fighters. Cardiopulmonary resuscitation (CPR) was started as the ambulance arrived shortly thereafter. Paramedics began advanced life support and transported the Chief to the hospital's emergency department where CPR and advanced life support treatment continued. Approximately 57 minutes after his collapse, the Chief died. The death certificate and the autopsy completed by the County Medical Examiner listed coronary artery disease as the cause of death. Given the Chief's underlying CAD, the physical stress of performing firefighting duties probably triggered a heart attack or a cardiac arrhythmia resulting in his sudden cardiac death.

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

- *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.*
- *Incorporate exercise stress tests following standard medical guidelines into the Fire Department's medical evaluation program.*
- *Ensure fire fighters are cleared for return to duty by a physician knowledgeable about the physical demands of firefighting, 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.*
- *Perform an annual physical performance (physical ability) evaluation to ensure fire fighters are physically capable of performing the essential job tasks of structural firefighting.*



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- *Provide fire fighters with medical clearance to wear a self-contained breathing apparatus (SCBA) as part of the Fire Department's medical evaluation program.*

## **INTRODUCTION & METHODS**

On September 12, 2007, a 56-year-old male volunteer Fire Chief suffered a fatal heart attack while responding to a structure fire. Despite CPR and advanced life support administered by emergency responders, the ambulance crew, and personnel in the hospital emergency department, the Chief died. NIOSH was notified of this fatality on September 12, 2007, by the United States Fire Administration. NIOSH contacted the affected Fire Department to gather additional information on September 19, 2007, and on September 5, 2008, to initiate the investigation. On September 24, 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:

- Current Fire Chief
- Assistant Chief
- Family members of the deceased Chief

NIOSH personnel reviewed the following documents:

- Fire Department policies and operating guidelines

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

## **RESULTS OF INVESTIGATION**

***Incident.*** On September 12, 2007, at approximately 0117 hours, the Fire Chief was awakened at his residence by a civilian stating that a vacant structure across the street was on fire. The civilian had also shouted this information while standing in the street, awakening a neighbor who called 911. The Chief ran outside to confirm that a fire was present. He then reentered his home to retrieve his portable radio when he subsequently collapsed.

The Fire Department, along with a police officer and an ambulance, were dispatched to the structure fire at 0121 hours. Units began arriving on scene at 0124 hours. Meanwhile, the Chief's daughter, hearing the commotion outside, came downstairs and found her father on the floor. She ran outside and alerted emergency responders of her father's condition. Some of the responders entered the home and



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began CPR. At 0127 hours, the ambulance, which was en route to the fire, was alerted to the Chief's condition.

The ambulance arrived on scene at 0128 hours, and paramedics located the Chief at 0131 hours. He was unresponsive, not breathing, had no pulse, with CPR in progress. The Chief was intubated and oxygen was administered; tube placement was confirmed by 1) visualization, 2) auscultation, and 3) secondary (technological) testing. A cardiac monitor was placed, revealing asystole. An intravenous line was begun, the Chief's blood sugar was measured (220 milligrams per deciliter [mg/dL]), and cardiac resuscitation medications were administered. He was placed onto a long back board, and although transcutaneous cardiac pacing resulted in electrical capture, no pulse returned and CPR continued. He was loaded into the ambulance, which departed the scene at 0147 hours en route to the hospital's emergency department. No positive change occurred in the Chief's condition during transport.

The ambulance arrived at the hospital at 0156 hours. Inside the emergency department, advanced life support treatment continued. One defibrillation (shock) was delivered successfully at 0203 hours, and a pulse returned (50 beats per minute). An electrocardiogram (EKG) revealed sinus bradycardia with atrioventricular dissociation and accelerated junctional rhythm with changes consistent with a heart attack. At 0213 hours, the Chief's heart rhythm reverted and remained in asystole. Resuscitation efforts continued until 0216 hours,

when the Chief was pronounced dead by the attending physician.

**Medical Findings.** The death certificate and autopsy completed by the County Medical Examiner listed coronary artery disease as the cause of death. Pertinent findings from the autopsy included coronary artery disease, cardiomegaly (enlarged heart), and left ventricular hypertrophy. Specific findings from the autopsy are listed in Appendix A.

The Chief was 70 inches tall and weighed 230 pounds, giving him a body mass index (BMI) of 33.0. A BMI >30.0 kilograms per meters squared (kg/m<sup>2</sup>) is considered obese [CDC 2008]. The Chief had a history of noninsulin dependent diabetes mellitus, complicated by diabetic neuropathy, diabetic retinopathy, and peripheral vascular disease. He also had high blood pressure (hypertension) and high blood lipids (hypercholesterolemia and hyperlipidemia). He was prescribed three antidiabetic medications but his compliance was poor, resulting in frequently elevated blood sugar levels (Hemoglobin A1C level of 8.4%). He was prescribed one medication for his high blood cholesterol 4 months prior to his death. It is unclear if this medication was effective as no further laboratory blood tests were performed. The Chief was prescribed three antihypertensive medications which successfully controlled his blood pressure. In 2001, his left foot was amputated due to complications from diabetes. In 2004, the Chief was hospitalized for symptoms resembling a stroke. Discharge diagnoses included uncontrolled hypertension, third nerve palsy due to diabetes, Tolosa-Hunt



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syndrome (an ophthalmoplegia caused by non-specific inflammation of the cavernous sinus or superior orbital fissure), noninsulin dependent (Type II) diabetes mellitus and peripheral vascular disease. The Chief also had a history of poor compliance with physician's advice regarding office visits and medical treatment.

He followed up regularly with his podiatrist and his ophthalmologist. He did not report heart-related symptoms (chest pain, chest pressure, angina, shortness of breath on exertion, etc.) to his physicians, his family, or the Fire Department. His last EKG approximately 1 year prior to his death showed normal sinus rhythm with first-degree atrioventricular block. The Fire Department was aware of the Chief's medical condition and restricted him from physically demanding duties.

## **DESCRIPTION OF THE FIRE DEPARTMENT**

At the time of the NIOSH investigation, the volunteer Fire Department consisted of one fire station with 52 uniformed personnel that served a population of 1,500 residents in a geographic area of 1.3 square miles.

In 2007, the Fire Department responded to 134 calls: 56 fires, 14 emergency medical calls, 8 rescue calls, 5 false alarms, and 51 other calls.

**Membership and Training.** The Fire Department requires all new fire fighter applicants to be at least 18 years of age, have a valid state driver's license, and pass a preplacement med-

ical evaluation (described below) and a drug test prior to being voted on by members of the Fire Department. New members receive fire fighter training in-house and at regional/state fire schools. Pennsylvania has no state minimum requirement for fire fighter certification. The Chief was certified as a Fire Fighter and had 35 years of fire fighting experience.

**Preplacement Medical Evaluation.** The Fire Department currently requires a preplacement medical evaluation for all new members regardless of age. Components of this evaluation include the following:

- Complete medical history
- Physical examination (including vital signs)

These evaluations are paid for by the Fire Department and performed by a Fire Department-contracted physician who determines medical clearance for fire fighting duties.

**Periodic Medical Evaluation.** Periodic (annual) medical evaluations are not currently required by the Fire Department. An annual SCBA facepiece fit test is required 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, and exercise (strength and aerobic)



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equipment is not available in the fire station. Health maintenance programs are not available from the City.

## DISCUSSION

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 Chief had six of the seven risk factors (all but family history).

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.

Establishing the occurrence of a recent (acute) heart attack requires characteristic EKG changes, elevated cardiac enzymes, and/or coronary artery thrombus. In the Chief's case, the EKG confirmed the occurrence of an acute (abrupt onset) heart attack. Additionally, the autopsy report listed evidence of an old (remote) heart attack(s).

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]. Given the Chief's underlying CAD and history of Type II diabetes mellitus, it is possible the stress of responding to the call triggered his heart attack which resulted in his subsequent cardiac arrest 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 2007a]. This voluntary industry standard provides minimum medical requirements for candidates and current fire fighters.

### Screening Tests for Cardiac Disease – Stress Tests.

Although stress testing asymptomatic individuals for CAD is somewhat controversial, it is recommended for a 56-year old male with six risk factors for CAD including diabetes mellitus with multiple complications [Gibbons et al. 2002; Blumenthal et al. 2007; NFPA 2007a]. A stress test was never recommended for the Chief. The Chief should not only have had a stress test, but the tests should have been occurring on a regular basis.

If a stress test had been performed, perhaps the Chief's underlying cardiac condition could have been identified, and he would have been referred for further evaluation and treatment.



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**Medical Requirements for Diabetic Fire Fighters.**

NFPA 1582 provides guidance for fire department physicians to follow when treating diabetic fire fighters. The standard states that fire fighters with diabetes mellitus who require treatment with insulin should be restricted from duty unless the member meets all of the following criteria:

- Is maintained by a physician knowledgeable in current management of diabetes mellitus on a basal/bolus regimen using insulin analogs
- Has demonstrated over a period of at least 1 year the motivation and understanding required to closely monitor nutritional therapy and insulin administration
- Has a dilated retinal exam by a qualified ophthalmologist or optometrist that shows no higher grade of diabetic retinopathy than microaneurysms
- Has normal renal function based on a calculated creatinine clearance greater than 60 milliliters per minute and absence of proteinuria
- Has no autonomic or peripheral neuropathy
- Has normal cardiac function without evidence of myocardial ischemia on cardiac stress testing (to at least 12 metabolic equivalent tasks [METS]) by EKG and cardiac imaging
- Has a signed statement from an endocrinologist knowledgeable in management of diabetes mellitus as well as the essen-

tial job tasks and hazards of fire fighting that the fire fighter meets the following criteria:

- Is maintained on a stable basal/bolus regimen using insulin analogs and has demonstrated over a period of at least 1 year the motivation and understanding required to closely monitor and control capillary blood glucose levels despite varied activity schedules through nutritional therapy and insulin administration
- Has achieved stable control of blood glucose as evidenced by Hemoglobin A1C consistently less than 8 when monitored at least twice yearly
- Does not have an increased risk of hypoglycemia due to alcohol use or other predisposing factors
- Has had no episodes of severe hypoglycemia in the preceding 1 year, with no more than one episode of severe hypoglycemia in the preceding 5 years
- Is certified not to have a medical contraindication to fire fighting training and operations [NFPA 2007a]

According to the records available to NIOSH, the Chief was not an insulin-dependent diabetic. However, he did not meet a single one of the criteria above. The Chief was already restricted from physically demanding fire fighter duties. However, responding to a fire alarm has



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been associated with elevated heart rates and on-duty sudden cardiac death [Barnard and Duncan 1975; Kales et al. 2003; Kales et al. 2007]. As Fire Chief of a volunteer fire department, he could still be required to fulfill many of the essential job tasks of a structural fire fighter [NFPA 2007a]. Specifically the following:

- wearing an SCBA
- wearing fire protective ensemble that is encapsulating and insulated
- unpredictable emergency requirements for prolonged periods of extreme physical exertion without benefit of warm-up, scheduled rest periods, meals, access to medication(s), or hydration
- operating fire apparatus or other vehicles in an emergency mode
- functioning as an integral component of a team, where sudden incapacitation of a member can result in mission failure or in risk of injury or death to civilians or other team members

## **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 Chief's collapse, his sudden cardiac death may have been prevented.

***Recommendation #1: Provide preplacement and annual medical evaluations to fire fight-***

***ers 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 2007a]. However, the Fire Department is 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 2007b].

To overcome the financial obstacle, 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 EMTs from the local Emergency Medical 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



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(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. Sharing the financial responsibility for these evaluations between fire fighters, the Fire Department, and physician volunteers may reduce the negative financial impact on recruiting and retaining needed fire fighters.

***Recommendation #2: Incorporate exercise stress tests following standard medical guidelines into the Fire Department's medical evaluation program.***

NFPA 1582, the IAFF/IAFC Fire Service Joint Labor Management Wellness/Fitness Initiative, and the ACC/AHA recommend an exercise stress test for male fire fighters over the age of 45 with two or more CAD risk factors [IAFF, IAFC 2000; Gibbons et al. 2002; NFPA 2007a]. The exercise stress test could be conducted by the fire fighter's personal physician or the City contract physician. If the fire fighter's personal physician conducts the test, the results must be communicated to the City physician, who should be responsible for decisions regarding medical clearance for fire fighting duties.

***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.***

Guidance regarding medical evaluations and examinations for structural fire fighters can be found in NFPA 1582 [NFPA 2007a] 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 [NFPA 2007b]. The physician should review job descriptions and essential job tasks required for all Fire Department 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.

***Recommendation #4: 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 2008]. Worksites 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



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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 over one million dollars 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 #5: Perform an annual physical performance (physical ability) evaluation to ensure fire fighters are physically capable of performing the essential job tasks of structural fire fighting.***

NFPA 1500, Standard on Fire Department Occupational Safety and Health Program, recommends that fire department members who engage in emergency operations be annually evaluated and certified by the fire department as having met the physical performance requirements identified in paragraph 10.2.3 of the standard [NFPA 2007b].

***Recommendation #6: 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 Protec-

tion 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, we recommend voluntary compliance with this OSHA standard.

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<sup>1</sup>Code 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).

## Appendix A: Autopsy Findings

- Coronary artery disease
  - Cardiomegaly (enlarged heart) (heart weighed 550 grams [g]; normal weight is <400 g) [Siegel 1997]
- Atherosclerotic CVD
  - Severe (90%) focal narrowing of the left anterior descending coronary artery



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- Moderate (75%) focal narrowing of the left circumflex coronary artery
- Moderate (70%) focal narrowing of the right coronary artery
- No evidence of recent thrombus (blood clot in the coronary arteries)
- Four areas of scarring in the apical region and left ventricular free wall
- Left ventricular hypertrophy
  - Left ventricle (1.4 centimeters [cm])
  - Interventricular septum (1.5 cm) (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])
- Normal cardiac valves
- No evidence of a pulmonary embolus (blood clot in the lung arteries)
- Blood tests for drugs and alcohol were negative

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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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