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Death in the line of duty...

NIOSH
Fire Fighter Fatality Investigation and Prevention Program

A summary of a NIOSH fire fighter fatality investigation *January, 2013*

Fire Fighter Suffers Sudden Cardiac Death While Performing Driver/Operator Duties at a Residential Structure Fire – New Jersey

Executive Summary

On January 19, 2012, a 58-year-old male volunteer driver/operator ("the D/O") and his fire department (FD) were dispatched at 1335 hours to a residential structure fire as part of a mutual aid program with a neighboring fire department. The D/O's FD was assigned as the rapid intervention team (RIT). At the scene, the D/O removed equipment from the RIT's rescue truck and straightened out kinks in the fire attack hoseline and then staged inside the rescue truck. A short while later, a bystander found the D/O slumped over the steering wheel and notified on-scene fire fighters. On-scene ambulance paramedics removed the D/O from the truck and found him to be unresponsive, not breathing, and without a pulse. Cardiopulmonary resuscitation (CPR) and advanced life support were begun. The D/O was transported at 1431 hours and arrived at the local hospital's emergency department (ED) at 1435 hours. Inside the ED, despite continuing cardiac resuscitation efforts, the D/O was pronounced dead at 1500 hours, and resuscitation efforts were stopped.

The death certificate and the autopsy report completed by the county medical examiner listed "sudden death due to combined effects of hypertensive and atherosclerotic cardiovascular disease and aortic valve stenosis" as the cause of death with polycystic kidney disease a contributing factor. Additional findings included coronary artery disease, cardiomegaly (enlarged heart), and left ventricular hypertrophy (LVH). Given the D/O's history of heart disease, NIOSH investigators concluded that the physical stress of responding to the call and straightening the hoseline may have triggered his sudden cardiac death.

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

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 a candidate and an annual physical performance (physical ability) evaluation for all members.

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

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Introduction & Methods

On January 19, 2012, a 58-year-old male volunteer D/O suffered sudden cardiac death while performing driver/operator duties at a residential structure fire. NIOSH contacted the affected FD on January 23, 2012, to gather additional information and on July 16, 2012, to initiate the investigation. On August 20, 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
- Fire commission board member
- Crew members
- D/O's spouse

NIOSH personnel reviewed the following documents:

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

Investigative Results

Incident. On January 19, 2012, the FD was dispatched at 1335 hours to a residential structure fire to provide mutual aid as the RIT. Responding in Rescue 1/8, the D/O and five crew members arrived at the scene at 1346 hours. Weather conditions included a temperature of about 30 degrees Fahrenheit (°F) and 56% relative humidity, giving a wind chill temperature of 24°F and a wet bulb globe temperature of 26°F [NOAA 2012]. Wet bulb globe temperature is a measure of ambient air temperature cooled by the evaporation of water from the wet temperature sensing element [NIOSH 1986].

Investigative Results (cont.)

The D/O assisted in removing equipment from the apparatus. Crew members set up their RIT equipment in front of the residence, while the D/O remained with the apparatus. As the primary FD continued fire extinguishment and needed additional hoseline, the D/O assisted with straightening the hoseline (removing kinks). Sometime around 1400 hours, the D/O entered the cab of Rescue 1/8. At 1423 hours, a passerby found him slumped over the steering wheel.

The on-scene ambulance crew was notified and removed the FF from the apparatus. Assessment revealed the D/O unresponsive, not breathing, and without a pulse. CPR was begun as an automated external defibrillator was placed; no shock was advised. CPR continued and oxygen was delivered via bag-valve mask. The D/O was placed into the ambulance, which departed the scene at 1431 hours en route to the hospital's ED.

The D/O arrived at the ED at 1435 hours where cardiac resuscitation efforts continued including cardiac monitoring, intubation, intravenous line placement, and the administration of cardiac resuscitation medications. The D/O's electrocardiogram briefly revealed low voltage QRS with probable idioventricular bradycardia, but his heart rhythm returned to pulseless electrical activity. Cardiac resuscitation efforts continued without success until 1500 hours when they were stopped, and the D/O was pronounced dead.

Medical Findings. The death certificate and the autopsy report completed by the county medical

Investigative Results (cont.)

examiner listed "sudden death due to combined effects of hypertensive and atherosclerotic cardiovascular disease and aortic valve stenosis" as the cause of death with polycystic kidney disease a contributing factor. Additional findings at autopsy included cardiomegaly (enlarged heart) and hypertrophy of the left ventricle. Other pertinent findings from the autopsy are listed in Appendix A.

The D/O had multiple medical problems. These included the following:

- Aortic stenosis: first noted in 1989 via a heart murmur (discussed in more detail below)
- Hypertension: diagnosed in 1975. The D/O was prescribed three blood pressure-lowering medications including a beta blocker, which achieved fair blood pressure control.
- Polycystic kidney disease: resulted in renal failure and a series of kidney transplants (last transplant in 1991). His kidney function was currently stable (creatinine about 1.3).
- Type II diabetes mellitus: discovered while on steroid medications for kidney transplant. He was maintained on oral medications with fair to poor control of his blood sugars (glucose range 121–215 milligrams per deciliter [mg/dL], hemoglobin A1c range 7.1–8.9). His diabetes was complicated by peripheral neuropathy (numbness) diagnosed in 2008.
- Popliteal deep vein thrombosis: diagnosed in 2006. The D/O was placed on coumadin (blood thinner).
- Hyperlipidemia and hypertriglyceridemia: diagnosed in 2006 and treated with a cholesterol-lowering medication.
- Obesity: He was 73 inches tall and weighed 265 pounds, giving him a body mass index of 35.0 kilograms per meter squared, which is considered obese [CDC 2011].

In August 2011, the D/O had an exercise stress test for his shortness of breath upon exertion. He exercised for 10 minutes, 18 seconds using a modified Bruce protocol. The test was stopped because of fatigue. The D/O reached 75% of his predicted maximal heart rate and achieved 7 metabolic equivalents (METs). This was interpreted as a low functional capacity for exercise. His electrocardiogram showed no ischemic changes and no arrhythmias; the D/O reported no chest pain. However, the D/O's systolic blood pressure dropped 8 millimeters of mercury (mmHg) at peak exercise (mild hypotension).

Because of his aortic stenosis, the D/O underwent annual echocardiograms; the most recent was in October 2011. This test revealed a calcified aortic valve with diminished opening (area of 1.09 cm2), a large pressure gradient (mean gradient of 63.9 mmHg), a calcified mitral valve apparatus, moderate LVH with an ejection fraction of 55%–60% (lower end of normal), and evidence of diastolic dysfunction. An aortic valve replacement was recommended, but a heart catheterization was conducted in November 2011 to assess his need for concurrent coronary artery bypass surgery. The catheterization revealed 80% stenosis in the left anterior descending coronary artery and 70% stenosis of the circumflex coronary artery. In December 2011, the D/O decided to have the valve replacement surgery, but he died (January 2012) before his surgery was scheduled.

The D/O did not participate in an exercise program and had recent complaints of increasing fatigue with associated chest discomfort while mowing his lawn. However, he served as a D/O without difficulty.

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Description of the Fire Department

At the time of the NIOSH investigation, the FD consisted of one fire station with 25 volunteer uniformed personnel. It served 5,000 residents in a geographic area of 1.5 square miles. The FD is part of a township fire department system that includes nine fire departments that cover 25 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, pass a background check, pass a urine drug test, and pass a preplacement medical evaluation (components are listed below). The new member is enrolled in the county fire academy to become trained to the Fire Fighter 1 level, after which the member is allowed to ride fire apparatus. The FD conducts two training drills per month. The D/O was certified as a Fire Fighter 2, Driver/Operator, technical rescue, incident command, and in hazardous materials operations. He had 38 years of fire fighting experience, including 10 years as a driver-operator and 1 year as fire chief.

Preplacement and Annual Medical Evaluations. A preplacement medical evaluation is required for all applicants. The components of the medical evaluation include the following:

- Complete medical history
- Physical examination (including vital signs)
- Audiogram
- Vision screen

These evaluations are performed by a local contract physician group based on New Jersey state guidelines. Once this evaluation is complete, the physician determines medical clearance for fire fighting duties, and forwards this decision to the FD. No annual medical evaluation is offered or required.

No annual clearance to wear a self-contained breathing apparatus is required. Ill members or members injured on duty must be cleared for duty by their primary care physician.

Health and Wellness Programs. The FD does not have a wellness/fitness program, and exercise equipment is not available in the fire station. However, a local health club offers discounted membership. No candidate or annual physical ability test is required.

Discussion

Aortic Stenosis and the Pathophysiology of Sudden Cardiac Death. Aortic stenosis is the narrowing of the aortic valve, which decreases the outflow of blood from the heart. It is the most common cardiac valve lesion in the United States and arises from congenital disorders (e.g., bicuspid valve) or from acquired conditions such as rheumatic fever, hypertension, endocarditis, connective tissue disorders, etc. [Sirois and Fatahzadeh 2001; Hoffman et al. 2004]. Condition severity is determined by the valve surface area: mild (1.5–2.0 centimeters squared [cm2]), moderate (1.0–1.5 cm2), or severe (<1.0 cm2) [Colen et al. 2002]. Symptoms typically develop when the valve surface area shrinks to ≤1.5 cm2. The most common symptoms are decreased exercise tolerance, fatigue, exertional shortness of breath, exertional angina, exertional light-headedness, or syncope [Boyle and Kramer 2001; Braunwald 2001; Sirois and Fatahzadeh 2001]. The D/O had aortic stenosis on the basis of his echocardiogram and began to suffer from exertional shortness of breath in September 2011. Two addi-

Discussion (cont.)

tional tests are commonly performed for prognostic information, an assessment of ventricular function (left ventricular ejection fraction) and an exercise stress test to assess cardiac reserve [Sirois and Fatahzadeh 2001; Carabello 2002a; Carabello 2002b]. The exercise stress test is contraindicated in symptomatic patients because of the risk of a sudden cardiac event but can be performed in asymptomatic patients under close physician observation.

Over time, the stenotic aortic valve results in a compensatory LVH, which increases the heart muscle mass without an increase in the ventricular chamber [Braunwald 2001; Sirois and Fatahzadeh 2001; Carabello 2002a]. This LVH increases the myocardial oxygen demand and decreases the diastolic blood flow through the coronary arteries, creating an imbalance between myocardial oxygen supply and demand [Sirois and Fatahzadeh 2001]. Medical management includes prophylactic antibiotic treatment for endocarditis and advising the patient to limit strenuous, unmonitored exercise because of the effect of LVH on coronary blood flow and risk of a sudden cardiac event. Valve replacement is indicated in patients with severe disease (valve surface area $\leq$ 1 cm2) [Braunwald 2001; Sirois and Fatahzadeh 2001; Carabello 2002b; Nishimura et al. 2008].

Disorders of the cardiac valves can adversely affect cardiac performance and place patients at risk for a cardiac emergency [Sirois and Fatahzadeh 2001; Carabello 2002]. Natural history studies show that once classic symptoms develop, average survival decreases to 5 years with the onset of angina, 3 years after cardiac syncope, and 2 years after heart failure [Carabello 2002b; Colen et al. 2002]. The incidence of sudden death increases from 1% to 2% annually among asymptomatic patients to 15%–20% among symptomatic patients [Otto 2000; Carabello 2002a; Carabello 2002b; Colen et al. 2002; Nishimura et al. 2008].

Atherosclerotic Coronary Heart Disease and Sudden Cardiac Death. In the United States, atherosclerotic coronary heart disease (CHD) is the most common risk factor for cardiac arrest and sudden cardiac death [Meyerburg and Castellanos 2008]. Risk factors for its development include three nonmodifiable factors (age older than 45, male gender, and family history of CHD) and five modifiable factors (smoking, hypertension, high blood cholesterol, obesity/physical inactivity, and diabetes) [AHA 2012; NHLBI 2012]. The D/O had four modifiable CHD risk factors (hypertension, high blood cholesterol, obesity/physical inactivity, and diabetes) and known moderate CHD by cardiac catheterization in November 2011, which was confirmed at autopsy.

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 D/O had responded to the alarm and performed driver/operator activities while wearing a driver's jumpsuit. These activities expended about 5 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

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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 D/O had six known conditions relevant to medical clearance: aortic valve stenosis, CHD, diabetes mellitus, deep vein thrombosis, use of blood thinner medication, and use of beta blocker medication.

Aortic Valve Stenosis. The D/O was diagnosed with aortic valve stenosis in 2006. NFPA 1582 identifies moderate to severe aortic valve stenosis as having a mean aortic valvular gradient greater than 20 mmHg and/or valve area less than or equal to 1.0 cm2. The D/O's mean aortic valve gradient was 63.9 mmHg, and his aortic valve area was 1.09cm2. NFPA 1582 considers moderate to severe aortic valve stenosis to compromise the member's ability to safely perform fire fighting tasks; wear encapsulating fire protective ensemble; climb six or more flights of stairs while wearing fire protective ensemble; search, find, and rescue-drag or carry victims; advance water-filled hoselines up to 2½-inches in diameter, meet unpredictable emergency requirements for prolonged periods of extreme physical exertion; and function as an integral component of a team where sudden incapacitation of a member can result in mission failure or in risk or injury or death to civilians or other team members [NFPA 2007a]. Therefore, according to NFPA 1582, the D/O should have been restricted from fire fighting duties.

Coronary Heart Disease. The D/O had CHD as evidenced by his cardiac catheterization. He had not reduced or eliminated any of his 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 2007a] if any of the following apply:

(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 METs
(5) Exercise-induced ischemia or ventricular arrhythmias observed by radionuclide stress test during an evaluation reaching at least a 12-MET 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 D/O met only one of these six criteria (no angina) and should have been restricted from fire fighting duties. In this case, the D/O did not perform fire fighting duties but served as a primary driver/operator.

Diabetes Mellitus. NFPA 1582 provides guidance for fire department physicians to follow when treating diabetic fire fighters [NFPA 2007a]. The standard states that fire fighters with diabetes mellitus that is controlled by diet, exercise, or oral hypoglycemic agents should be restricted from duty unless the member meets all of the following criteria:

(1) If on oral hypoglycemic agents, has had no epi-

Discussion (cont.)

sodes of severe hypoglycemia (defined as requiring assistance of another in the preceding year)
(2) Has achieved a stable blood glucose as evidenced by HA1C level less than 8 during the prior 3-month period
(3) Has a dilated retinal exam by a qualified ophthalmologist or optometrist that shows no higher grade of diabetic retinopathy than microaneurysms
(4) Has normal renal function on the basis of a calculated creatinine clearance greater than 60 milliliters per minute and absence of proteinuria
(5) Has no autonomic or peripheral neuropathy
(6) Has normal cardiac function without evidence of myocardial ischemia on cardiac stress testing (to at least 12 METs) by EKG and cardiac imaging [NFPA 2007a].

The D/O's diabetes was being managed with oral medications. He met only two of these six criteria (no episodes of hypoglycemia and no high grade retinopathy) and should have been restricted from fire fighting duties. Again, the D/O served as a primary driver/operator.

Deep Vein Thrombosis and Anticoagulation Therapy. The D/O was diagnosed with venous thrombosis in June 2006 when he was hospitalized for right leg pain. NFPA 1582 considers deep venous thrombosis and full-dose anticoagulation to compromise a member's ability to safely perform fire fighting tasks, wearing encapsulating fire protective ensemble, climbing six or more flights of stairs while wearing fire protective ensemble, advancing water-filled hoselines up to 2½ inches in diameter, and unpredictable emergency requirements for prolonged periods of extreme physical exertion [NFPA 2007a]. The D/O was prescribed coumadin for deep vein thrombosis. Therefore, he should have been restricted from fire fighting duties. Even though the D/O's primary duty was as a driver/operator of fire apparatus, he actively participated in moderately strenuous activities in training and during emergency responses.

Beta Blocker Therapy. The D/O was diagnosed with hypertension in 1975. He was prescribed a beta blocker beginning in 2006. The NFPA considers use of beta blockers to potentially preclude safely wearing the fire protective ensemble and safely climbing ladders, operating from heights, walking or crawling in the dark along narrow and uneven surfaces, and operating near electrical power lines or other hazards because of the risk for dehydration, electrolyte disorders, lethargy, and disequilibrium [NFPA 2007a]. Thus, according to NFPA 1582, he should have been restricted from fire fighting duties.

In summary, the D/O should have been restricted from full fire suppression duties because of any of the following: aortic stenosis, CHD, diabetes, deep vein thrombosis with full-dose anticoagulation, and beta blocker medication.

Even though the D/O was not a suppression fire fighter, he did perform strenuous activities as required of a driver/operator.

Left Ventricular Hypertrophy/Cardiomegaly. The D/O's echocardiogram and his autopsy revealed LVH and cardiomegaly. These conditions 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 hypertension, a heart valve problem, or chronic cardiac ischemia (reduced blood supply to the heart muscle) [Siegel 1997]. The D/O's history of hypertension and his aortic stenosis were responsible for his left ventricular hypertrophy and cardiomegaly.

Recommendations

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

Recommendation #1: 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. However, the FD is not legally required to follow the NFPA standard or the IAFF/IAFC initiative. In addition, 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 #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 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 D/O had five conditions (CHD, hyperglycemia, deep vein thrombosis, full-dose anticoagulation treatment, and beta

Recommendations (cont.)

blocker medication) that, according to NFPA 1582, should have precluded him from unrestricted duty [NFPA 2007a].

Recommendation #3: 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 #4: Perform a candidate and 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]. The annual evaluation could be incorporated into the annual task-level training program.

Recommendation #5: 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. New Jersey operates an OSHA-approved state plan [OSHA 2012]; therefore, the FD is required to ensure all structural fire fighters have been medically cleared to wear a respirator/SCBA.

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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), 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, led the investigation and co-authored the report. Dr. Thomas Hales (MD, MPH), a member of the NFPA Technical Committee on Occupational Safety and Heath, and Vice-Chair of the Public Safety Medicine Section of the American College of Occupational and Environmental Medicine (ACOEM), provided medical consultation and co-authored the report.

Appendix A

Autopsy Findings

- Hypertensive heart disease
  - Cardiomegaly (enlarged heart; heart weighed 775 grams [g]; predicted normal weight is 429 g [ranges between 325 g and 566 g as a function of sex, age, and body weight]) [Silver and Silver 2001]
  - Left ventricular hypertrophy
    - Left ventricle thickened (1.9 centimeter [cm])
    - Interventricular septum thickened (3.0 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 (60%) focal narrowing of the right coronary artery
  - No evidence of a coronary artery thrombus (blood clot)
- Aortic and mitral valve stenosis
  - Dystrophic calcification of the aortic valve cusps and anterior leaflet of mitral valve
- Dilated cardiomyopathy
  - Focal areas of slightly increased perivascular and interstitial fibrous tissue
  - Myocyte hypertrophy without disarray
- Polycystic kidney disease
- No evidence of a pulmonary embolus (blood clot in the lung arteries)
- Blood tests for drugs and alcohol were negative

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