



After Conducting Fire Suppression Duties at a Structure Fire, Captain Collapses in Incident Scene Rehabilitation – Kansas

SUMMARY

On August 13, 2007, a 44-year-old Captain reported for duty at 0700 hours. At 1819 hours his crew was dispatched to a multiunit apartment fire. At this time the air temperature was 97 degrees Fahrenheit (°F) with a relative humidity (RH) of 35%. Initial size-up reported heavy smoke from the two-story wood frame apartment building. The Captain, wearing turnout gear and his self contained breathing apparatus (SCBA), secured water supply to the first-in Engine with a 5-inch diameter hose. He was then assigned to assist with a primary search on the second floor of the apartment building. After being on-scene for about 10 minutes, the Captain was assigned to incident scene rehabilitation (Rehab). While in Rehab, he collapsed. Emergency medical service (EMS) personnel staffing the Rehab area immediately loaded the Captain into the ambulance and began advanced life support including cardiopulmonary resuscitation (CPR). Despite resuscitation efforts in the ambulance and in the Emergency Department, the Captain never regained consciousness. The death certificate and autopsy listed “Coronary Atherosclerosis” as the immediate cause of death and high heat conditions as a contributory cause. NIOSH investigators concluded that engaging in firefighting activities on a hot day probably triggered a heart attack and the Captain’s subsequent sudden cardiac death.

NIOSH offers the following recommendations to reduce the risk of on-the-job heart attacks and sudden cardiac arrest among fire fighters at this and other fire departments across the country.

- Provide mandatory pre-placement and periodic medical evaluations to all fire fighters consistent with the National Fire Protection Association (NFPA) 1582, Standard on Comprehensive Occupational Medical Program for Fire Departments.
- Ensure fire fighters are cleared for 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.
- Provide fire fighters with medical clearance to wear self-contained breathing apparatuses (SCBAs) as part of the Fire Department’s medical evaluation program.
- Ensure that appropriate systems are in place to identify fire fighters who do not participate in medical evaluations.
- Develop a comprehensive wellness/fitness program for fire fighters to reduce risk factors for cardiovascular (CVD) and improve cardiovascular capacity.



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INTRODUCTION & METHODS

On August 13, 2007, a 44-year-old Captain responded to a multiunit apartment building fire. After performing fire suppression and search and rescue duties for about 10 minutes, he collapsed in the on-scene Rehab area. Despite CPR and advanced life support in Rehab, the ambulance, and the Emergency Department, the Captain died. NIOSH was notified of this fatality on August 14, 2007 by the United States Fire Administration. NIOSH contacted the affected fire department shortly thereafter to obtain further information, and again on June 20, 2008, to schedule the investigation. On September 28, 2008 a contractor for the NIOSH Fire Fighter Fatality Investigation Team (the NIOSH investigator) travelled to Kansas to conduct an on-site investigation of the incident.

During the investigation, the NIOSH investigator interviewed the following people:

- Fire Chief
- Deputy Fire Chief
- Training Officer
- Local Union President
- Crew members working with the Captain on the day of the incident
- Incident commander of the incident
- Safety Officer
- Medical Examiner
- Captain's spouse

The NIOSH investigator reviewed the following documents in preparation of this report:

- Fire department incident report
- Dispatch records
- Ambulance report
- Death certificate
- Autopsy
- Hospital records
- Department operating procedures
- Captain's training records

INVESTIGATIVE RESULTS

Incident Response. On August 13, 2007, the Captain reported to duty at 0700 hours for his 24-hour shift. During his shift the Captain responded to three calls. At 1223 hours the crew was dispatched to the scene of a motor vehicle accident. They arrived at 1230 and were on-scene for approximately 9 minutes. At 1316 the crew responded to a false, unintentional smoke detector activation. At 1819 hours a structure fire was reported at a multiunit apartment building. Initial size-up reported heavy smoke and high ambient temperatures (97°F, 35% RH), prompting the Incident Commander to call for a second alarm. The Captain and his crew were part of the first alarm response. They arrived on scene at 1824 hours and assisted in laying a supply hose (5 inches in diameter) to the first-in Engine. The supply hose was not securely attached to the hydrant and when the valve was opened the hose struck the Captain in the back of his legs. The Captain



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reported that he was not seriously injured. At approximately 1829 hours, the Captain was assigned to assist the truck company conducting search and rescue operations on the second floor of the structure. At 1833 hours the primary search was completed and the Incident Commander assigned the Captain and his crew to incident-scene Rehab.

The Captain and his crew walked to Rehab, stopping briefly at their Engine to talk. The Captain entered Rehab and while removing his bunker pants, he collapsed. Emergency medical service personnel who were staffing the Rehab area immediately loaded the Captain into the on-scene ambulance.

Patient care in the ambulance began at approximately 1838 hours by an advanced life support team that included a paramedic. CPR was initiated and oxygen was delivered via a bag-valve mask. An electrocardiogram (EKG) revealed that the Captain was in ventricular tachycardia, and he was shocked at 200 joules with no change in his heart rhythm or clinical status. Additional shocks were administered at 300 joules, again without a change in his clinical status. An intravenous line was inserted and epinephrine was administered per advanced life support protocols. CPR was performed throughout transport.

The Captain arrived in the Emergency Department at 1851 hours. An assessment revealed that the Captain was pulseless, unresponsive, and cyanotic. Advanced life support protocols were continued for an additional 12 minutes, but resuscitation efforts were unsuccessful and

he was pronounced dead at 1903 hours.

Medical Findings. The death certificate, completed by the Medical Examiner, listed "Coronary Atherosclerosis" as the cause of death with hot conditions being listed as a contributing cause. Pertinent findings from the autopsy, performed August 14, 2007, showed an enlarged heart with evidence of remote (old) heart attacks and coronary artery procedures. Pertinent detailed findings from the autopsy can be found in Appendix A.

The Captain had a long and extensive history of cardiovascular disease. The Captain had his first heart attack in 1993 at the age of 30. He had his second heart attack in 2000 at the age of 37. In 2000 he underwent a coronary catheterization and had an intra-coronary stent placed. Ten months later he had a "symptom limiting" exercise stress test as part of his Fire Department medical evaluation. He exercised for 10 minutes and 33 seconds reaching Stage V of a modified Bruce protocol (2 minute stages). The test was stopped due to fatigue. During exercise and recovery the Captain related no chest pain, no significant arrhythmia, and no EKG changes suggestive of ischemia. He had a somewhat hypertensive response to exercise, peak blood pressure = 190/94 mmHg which declined to 150/92 mmHg at 5 minutes of recovery. The Fire Department physician reported that the Captain had an excellent exercise capacity. After 2000, the Fire Department did not conduct any subsequent exercise stress tests. If additional exercise stress tests or tests of his ventricular function were performed by his private physicians, the results were not for-



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warded to the Fire Department physician, nor were results available to NIOSH at the time of this report.

The Captain's last Fire Department medical evaluation was in June 2004. This revealed a moderately elevated blood pressure (147/92 mmHg) despite medication, high blood cholesterol [307 milligram per deciliter (mg/dl)], and high blood glucose (118 mg/dl). He had a body mass index of 34.1, which placed him in the obese category [CDC 2009]. The Captain was a non-smoker who was recreationally active (golfing) and reportedly performed aerobic exercise on most duty days.

Technician. The Captain routinely participated in education and training provided by the Department and had taken Independent Study courses in Basic Incident Command and National Incident Management System (NIMS).

Pre-placement Medical Evaluations. A pre-placement medical evaluation is required of all new recruits. The pre-placement medical evaluations are performed by a physician's group under a contract to the City and include a medical history, blood pressure measurement, physical examination, blood work for complete blood cell count and cholesterol, urinalysis, drug screen, spirometry, resting EKG, hearing test, and vision test.

DESCRIPTION OF THE FIRE DEPARTMENT

The fire department (FD) consisted of approximately 240 fire fighters. It has 12 fire stations and serves a population of approximately 120,000 residents. The FD covers an area of approximately 60 square miles. The FD responded to over 14,000 calls in 2007, of which approximately 700 were fire calls.

Employment and Training. The FD requires applicants to take a general aptitude test, complete a physical ability test, and be interviewed. Top candidates must pass a pre-placement medical evaluation before they are hired. The Captain was hired in 1990 and advanced through the rank of aerial operator and lieutenant, becoming a Captain in 2003. He was a certified Emergency Medical Technician – Intermediate and was a Hazardous Materials

Periodic Medical Evaluations. Annual medical evaluations of all uniformed fire fighters are required by the FD. The components of the annual medical evaluation are the same as the pre-placement medical evaluations except that a drug screen and resting EKG are not performed. The same physician group conducting the pre-placement medical evaluations conducts the periodic evaluation. At the end of the evaluation, the health care provider completes a FD work form that indicates that the fire fighter has been examined and

- “can perform the essential function of the position without accommodation
- can perform the essential function of the position with accommodations (recommended accommodations _____)
- cannot perform the functions of the posi-



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- tion without accommodations
- further testing recommended (recommended tests _____), or
 - follow-up with personal physician recommended, return after evaluation.”

Following the Captain's heart attack and stent placement in 2000, he was enrolled in a cardiac rehabilitation program which he attended for about one month. He stopped attending the cardiac rehabilitation at approximately the same time he returned to work.

The Captain did not have a departmental medical evaluation after 2004. Company officers schedule their crews for their medical evaluations while on duty. In this case, the Captain was responsible for scheduling his crew. Apparently, he scheduled his crew, but failed to schedule his own medical evaluation.

Fitness/Wellness Programs. The FD has access to a voluntary health and wellness program through the city. Individual fire stations have some aerobic exercise equipment but there is no formal exercise program in place.

DISCUSSION

CAD and the Pathophysiology of Sudden Cardiac Death. This Captain suffered sudden cardiac death after performing firefighting activities. The most common risk factor for cardiac arrest and sudden cardiac death is coronary artery disease (CAD), defined as the build-up of atherosclerotic plaque in the coronary arteries [AHA 2009]. This Captain had

CAD as defined by his heart attack in 1993 and his findings at autopsy.

The narrowing of the coronary arteries by atherosclerotic plaques occurs over many years, typically decades [Libby 2005]. However, the growth of these plaques probably occurs in a nonlinear, often abrupt fashion [Shah 1997]. Most heart attacks occur when a vulnerable plaque ruptures, causing a blood clot to form which occludes a coronary artery. This Captain had two known previous heart attacks and the autopsy revealed significant coronary artery disease in both the right and left coronary arteries. Based on his history and the results of the autopsy, it appears that this death was caused by a myocardial infarction (heart attack).

The Captain collapsed shortly after arriving at Rehab. He had been on scene for approximately 14 minutes prior to his collapse. He helped lay the line from the hydrant to the engine and then was assigned to assist with the primary search on the second floor of the burning building. Despite the relatively short time on scene, the combination of wearing fully encapsulating gear, climbing stairs, and engaging in fire suppression activities in extreme environmental conditions would be expected to cause considerable cardiovascular strain.

Firefighting is widely acknowledged to be physically demanding. Firefighting activities require fire fighters to work at near maximal heart rates for long periods. The increase in heart rate typically occurs in response to the initial alarm and persists throughout the course



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of fire suppression activities [Barnard and Duncan 1975; Lemon and Hermiston 1977; Manning and Griggs 1983; Smith et al. 2001]. Even when energy costs are moderate (as measured by oxygen consumption) and work is performed in a thermoneutral environment, heart rates may be high (over 170 beats per minute) owing to the insulative properties of the personal protective clothing [Smith et al. 1995].

Epidemiologic studies in the general population have found that heavy physical exertion can trigger a heart attack and cause sudden cardiac death [Tofler et al. 1992; Mittleman et al. 1993; Willich et al. 1993; Albert et al. 2000]. Epidemiologic studies among fire fighters have shown that fire suppression, training, alarm response, or strenuous physical activity on the job in the preceding 12 hours, increases the risk for a sudden cardiac event [Kales et al. 2003; Hales et al. 2007; Kales et al. 2007]. The Captain was involved in alarm response and in moderate physical activity while working to secure the water supply and during his participation in the primary search.

Based on the findings discussed above, the NIOSH investigator concluded that the Captain died from a probable heart attack triggered by performing firefighting activities under extreme environmental conditions.

Occupational Medical Standards for Structural Firefighting To reduce the risk of sudden cardiac arrest or other incapacitating medical conditions among fire fighters, the NFPA has developed NFPA 1582. The 2000 edition of NFPA 1582 considered that fire fighters with coronary artery disease have a “category B” condition defined as “A medical condition that, based on its severity, could preclude a person from performing as a member in a training or emergency operational environment by presenting a significant risk to the safety and health of the person or others” [NFPA 2000]. The 1582 appendix says that persons with a history of a heart attack are acceptable for fire fighting if they are at “mildly increased risk for sudden incapacitation” which is defined by all of the following:

1. normal left ventricular ejection fraction;
2. normal exercise tolerance, > 10 metabolic equivalents (METS);
3. absence of exercise-induced ischemia by exercise testing;
4. absence of exercise-induced complex ventricular arrhythmias; and
5. absence of hemodynamically significant stenosis in all major coronary arteries ($\geq 50\%$ lumen diameter narrowing), or successful myocardial revascularization.

The Captain appeared to fulfill the 2000 NFPA criteria for return to work when he returned in February of 2000. An echocardiogram completed as part of his medical evaluation in Oc-



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tober of 2000 found a normal left ventricular ejection fraction (65%).

The 2007 edition of NFPA 1582 modified this guidance [NFPA 2007a] for members suffering a previous heart attack, “the physician shall report the applicable job limitations to the fire department if any one of the following is present:

1. Current angina pectoris even if relieved by medication
2. Persistent significant stenosis in any coronary artery (greater than 70 percent 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 less than 42 mL O₂/min/kg or less than 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 greater than or equal to 180 or low density lipoproteins greater than or equal to 100 despite treatment, or glycosylated hemoglobin greater than 7 despite exercise and/or weight reduction)

Based on his 2000 exercise stress test and his medical tests in 2004, the Captain did not meet the 2007 NFPA criteria for return to unrestricted duty. Perhaps if the Captain continued to receive fire department annual medical evaluations, including periodic exercise stress tests and tests of left ventricular function, his persistent coronary artery disease could have been indentified and his sudden cardiac death prevented at this time.

RECOMMENDATIONS

NIOSH offers the following recommendations to reduce the risk of on-the-job heart attacks and sudden cardiac arrest among fire fighters at fire departments across the country.

Recommendation #1: Provide mandatory annual medical evaluations to all fire fighters consistent with NFPA 1582 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 periodic medical evaluations and examinations for fire fighters can be found in NFPA 1582 and in the International Association of Fire Fighters/International Association of Fire



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Chiefs (IAFF/IAFC) Fire Service Joint Labor Management Wellness/Fitness Initiative [IAFF 2000; NFPA 2007a]. This FD had adopted required annual medical evaluations at the time of the Captain's death, but the Captain had not complied with that requirement for 3 years.

Recommendation #2: Ensure fire fighters are cleared for 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.

Physicians who provide input regarding medical clearance for firefighting duties should be knowledgeable about the unique physical demands of firefighting that result from the combination of strenuous physical work, heavy and encapsulating personal protective ensembles, extreme ambient temperatures, and emotional stress. Physicians should also be familiar with a fire fighter's personal protective equipment and the consensus guidelines published by NFPA 1582 [NFPA 2007a].

Recommendation #3: Provide fire fighters with medical clearance to wear self-contained breathing apparatuses (SCBAs) as part of the fire department's medical evaluation program.

The Occupational Safety and Health Administration (OSHA)'s Revised Respiratory Protection Standard requires employers to provide medical evaluations and clearance for employees using respiratory protection [CFR 1998]. Such employees include fire fighters who use

SCBA in the performance of their duties. These clearance evaluations are required for private industry employees and public employees in States operating OSHA-approved State plans. Kansas does not operate an OSHA-approved State plan; therefore, public sector employers are not required to comply with OSHA standards [U.S. Department of Labor 2006]. Nonetheless, we recommend following this standard to ensure fire fighters are medically able to wear SCBA.

Recommendation #4: Ensure that appropriate systems are in place to identify fire fighters who do not participate in annual medical evaluations.

This FD requires annual medical evaluations for its members. However, for 3 years the Captain did not receive his medical evaluation (2005-2007). The Fire Department lacked a system to identify fire fighters not completing their medical evaluations. Current practice has company officers scheduling their crews for medical evaluations. In this case, the Captain was responsible for scheduling his crew. Apparently, he scheduled his crew, but failed to schedule his own. The FD had no formal mechanism to identify that this had occurred, nor are there any established departmental policies regarding actions to be taken in the case of a fire fighter who does not have a medical exam. NIOSH suggests that systems be established to clearly identify if a fire fighter has missed an annual medical examination. Fire Fighters should not be cleared for duty until their annual medical evaluation is complete.



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Recommendation #5: Develop a wellness/fitness program for fire fighters to reduce risk factors for CVD and improve cardiovascular capacity.

Physical inactivity is the most prevalent modifiable risk factor for CAD in the United States. Physical inactivity, or lack of exercise, is an independent risk factor for CAD and it is positively associated with other risk factors including, obesity, dyslipidemia, and diabetes [Plowman and Smith 2003]. NFPA 1500 requires a wellness program that provides health promotion activities for preventing health problems and enhancing overall well-being [NFPA 2007]. Guidance for how to implement and components of a wellness and fitness program can be found in several documents provided by Fire Service organizations:

- NFPA 1583, Standard on Health-Related Fitness Programs for Fire Fighters [NFPA 2008];
- International Association of Fire Fighters/International Association of Fire Chiefs (IAFF/IAFC), Fire Service Joint Labor Management Wellness/Fitness Initiative [NFPA 2007];
- National Volunteer Fire Council (NVFC) / United State Fire Administration (USFA) Health and Wellness Guide for the Volunteer Fire Service [National Volunteer Fire Council 2004].

Implementing a Health and Wellness program should be a top priority of fire departments and should be a collaborative effort between the administration and the union.

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Fatality Assessment and Control Evaluation
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INVESTIGATOR INFORMATION

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Appendix A: Pertinent findings from the Autopsy.

- Cardiomegaly (enlarged heart)
- Marked calcified atherosclerosis of the right coronary artery and the anterior descending portion of the left main coronary artery
- Myocardial scar involving the septum
- Metallic stent within the right coronary artery
- Carbon monoxide less than 10%

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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