

LINE OF DUTY DEATH REPORT

F2021-04 • March 1, 2021

1000 FREDERICK LANE, MORGANTOWN, WV 26508 • 304.285.5916

54-Year-Old Interim Fire Captain Suffers Sudden Cardiac Event During Physical Ability Test—New Hampshire

Executive Summary

A 54-year-old career interim fire captain (CAPT) experienced chest pain and collapsed during a physical ability test that he was performing in order to be rehired as a fire captain after several years of retirement. Firefighters and paramedics on-scene immediately initiated care and the CAPT was defibrillated several times before a transport ambulance arrived. Continued resuscitation efforts en route and in the emergency department were unsuccessful.

The medical examiner's report listed the cause of death as atherosclerotic coronary artery disease. The autopsy found advanced underlying cardiovascular disease with near total blockages by advanced plaque in each of the three main arteries of the heart, and evidence of two old heart attacks that had damaged the heart muscle. National Institute for Occupational Safety and Health (NIOSH) investigators concluded that the physical ability test triggered a sudden cardiac event in an individual with advanced coronary artery disease and pre-existing cardiac damage.

Key Recommendations

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

- *Key Recommendation #1: Phase in a comprehensive wellness fitness program.*
- *Key Recommendation #2: Medical evaluations for rehires should occur within 3–6 months of the rehire date and before the candidate takes the pre-hire candidate physical ability test.*

The National Institute for Occupational Safety and Health (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 Web site at www.cdc.gov/niosh/fire or call toll free 1-800-CDC-INFO (1-800-232-4636).

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Introduction

On August 31, 2020, at approximately 1255 hours, an interim training captain (CAPT), who had just taken a physical ability test as part of a rehiring process to return to the department after several years of retirement, experienced chest pain and collapsed. On scene personnel initiated care immediately and the CAPT was transported to an emergency department (ED) where he was pronounced dead. In March 2021, a contractor for the National Institute for Occupational Safety and Health (NIOSH) Fire Fighter Fatality Investigation and Prevention Program (the NIOSH investigator) conducted a series of telephone interviews to investigate the incident.

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

- *Chief*
- *Interim director of training academy*
- *Captain's wife*
- *Medical examiner*
- *Fire marshal*

The NIOSH investigator reviewed the following documents:

- *FD records*
- *Emergency medical services (EMS) (ambulance) report*
- *ED records*
- *Occupational medical records*
- *Autopsy report*

Fire Department

At the time of the NIOSH investigation, the fire department (FD) consisted of 17 full-time firefighters and officers and approximately 40 part-time and active on-call firefighters operating out of 3 fire stations. It serves a population of approximately 19,000 in a geographic area of about 38 square miles.

54-Year-Old Interim Fire Captain Suffers Sudden Cardiac Event During Physical Ability Test—New Hampshire

Membership and Training

Applicants must be at least 18 years of age, have a high school diploma or equivalent, possess a valid driver's license, be a resident of the state and have passed the candidate physical ability test (CPAT). Potential members complete an application and top candidates are interviewed by a board consisting of firefighters, officers, and chief officers. Successful candidates progress to an interview with the Chief. Contingent offers are made based on a background check and successful completion of a medical evaluation. The CAPT had been with the FD for 30 years before retiring in May 2015. He then returned to serve as the interim fire chief and stayed with the FD on a part-time basis. He decided to return to full-time status as a training captain, which, according to state law, required that he pass the CPAT test.

Preplacement/Periodic/Return to Work Medical Evaluations

The FD requires pre-placement medical evaluations for applicants and annual medical evaluations for incumbents. Components of the medical evaluation are the same for both groups except a urine drug screen is performed for candidates. Components of the medical evaluation are consistent with National Fire Protection Association (NFPA) 1582 Standard [NFPA 2018].

Firefighters must be medically cleared by the designated fire department physician (often, but not required to be an occupational health physician) before returning to work following a serious injury or illness.

Wellness/Fitness Programs

The Fire Department has fitness equipment and fitness programming (i.e., exercise classes, etc.) available to firefighters at all 3 stations through the wellness program offered by the town. However, the FD does not require that firefighters participate in the fitness program. The CAPT was actively engaged in outdoor activities of hunting and fishing. He had also been going to the gym regularly for over a year.

Investigation

Following his retirement in 2015, the CAPT was asked to return as interim Chief in May of 2019 (when he was 53 years old). He then served as interim Chief for 3 months, before moving to serve as both the interim Deputy Chief and the Training Captain. While serving as the interim Training Captain, he decided that he would like to return to the FD in that role on a full-time basis. The CAPT had his medical evaluation as required for his rehire in September 2019 and was cleared for duty. This medical evaluation did not document any prior heart attack or cardiac issues.

Based on State requirements and departmental policy, all full-time members are required to pass a physical ability test. On August 31, 2020, at approximately 1230 hours, the 54-year-old CAPT began the CPAT which consisted of a 3-minute (min) stair climb (on a StepMill machine) while wearing a 75-pound shoulder weight, a hose drag, equipment carry, ladder raise and extension, forcible entry, search and rescue, and ceiling breach and pull [IAFF 2007]. The CAPT passed the course and was sitting in a chair provided for candidates to recover. Shortly after being seated, the CAPT notified a

54-Year-Old Interim Fire Captain Suffers Sudden Cardiac Event During Physical Ability Test—New Hampshire

staff member that he was experiencing chest pains and was lowered to the ground by test proctors. Witnesses reported that he was pale and clammy. At 1255, the transporting EMS agency was notified as there was not an advanced life support/basic life support (ALS/BLS) unit present during the CPAT. On scene personnel initiated cardiopulmonary resuscitation (CPR), attached a manual defibrillator, and provided two shocks as advised.

EMS arrived on scene at 1302 hours and found the CAPT pulseless and not breathing with CPR in progress. The cardiac rhythm was ventricular tachycardia (VT). Paramedics provided oxygen via non-rebreather mask, obtained IV access and administered cardiac medications (3 rounds of epinephrine and amiodarone), secured the airway with an Ambu[®] King LTS-D[™] laryngeal tube airway, provided mechanical compression using a Lucas[®] chest compression device, and defibrillated the CAPT. The CAPT's cardiac rhythm alternated between VT and ventricular fibrillation (VF) throughout transport.

The ambulance arrived at the ED at 1321 hours at which time the CAPT was noted to be unresponsive, his pupils were nonreactive, and cardiac rhythm was VF which quickly converted to pulseless electrical activity (PEA). The CAPT was given one more dose of amiodarone and 4 more doses of epinephrine. Endotracheal intubation was performed with proper positioning determined by direct visualization, chest auscultation, end tidal capnography, and chest x-ray. Bedside cardiac ultrasound confirmed that there was no cardiac movement. At 1337 hours, the CAPT was pronounced dead.

Medical Findings

The medical examiner's report identified the cause of death as atherosclerotic coronary artery disease. There were two discrete areas of previous injury to the heart muscle reflecting prior heart attacks but there was no mention of previous heart attacks in the CAPT's medical records so he may not have been aware of their occurrence or had not sought treatment on developing symptoms. Each of the three main arteries (right coronary artery, left circumflex coronary artery, and left anterior descending coronary artery) were almost completely blocked by calcified plaque meaning he had severe triple vessel coronary heart disease. Both the left anterior descending artery and the right coronary artery had evidence of fresh and remote plaque hemorrhage. There was no intracoronary thrombosis noted. The heart was enlarged, weighting 530 grams, but there was no dilation of the chambers or hypertrophy of their walls.

Return to Work Medical Evaluation Findings

The CAPT had received a medical evaluation as part of his rehiring process in September of 2019 and was cleared to perform all essential job functions without restrictions. The CAPT also received medical clearance for a commercial driver's license (CDL). On the CDL form he noted that he had high cholesterol but provided a clarifying statement that he controlled his cholesterol with diet. The CAPT was 6'2" and weighed 181 pounds, giving him a body mass index (BMI) of 23.2 kilograms per square meter (kg/m²).

54-Year-Old Interim Fire Captain Suffers Sudden Cardiac Event During Physical Ability Test—New Hampshire

Table 1. Cardiovascular disease risk factors and associated category of risk.

Risk Factor	Interpretation	Category Guidelines
Systolic BP ¹	Normal Elevated Stage 1 Hypertension Stage 2 Hypertension	< 120 mmHg 120–129 mmHg 130–139 mmHg ≥ 140 mmHg
Diastolic BP ¹	Normal Elevated Stage 1 Hypertension Stage 2 Hypertension	< 80 mmHg >80 mmHg 80–89 mmHg ≥ 90 mmHg
Total Cholesterol ²	Desirable Borderline High High	< 200 mg/dL 200–239 mg/dL ≥ 240 mg/dL
HDL ²	Low High (Desirable)	< 40 mg/dL ≥ 60 mg/dL
LDL ²	Optimal Above normal Borderline high High	< 100 mg/dL 100–129 mg/dL 130–159 mg/dL > 160 mg/dL
Triglycerides ³	Normal Hypertriglyceridemia Severe hypertriglyceridemia	> 175mg/dL 175–499mg/dL ≥ 500mg/dL
Blood Glucose ⁴	Normal Prediabetes Diabetes	< 100 mg/dL 100–125 mg/dL ≥ 126 mg/dL
BMI ⁵	Underweight Normal weight Overweight Obesity	< 18.5 kg/m ² 18.5–24.9 kg/m ² 25–29.9 kg/m ² ≥ 30 kg/m ²

¹Whelton et al. 2018 ²Kratz 2004, ³Grundy et al. 2019, ⁴ADA 2014, ⁵CDC 2020

Table 1 summarizes the CAPT's cardiovascular disease risk factors at the time of his death. The CAPT's blood pressure of 118/76 millimeters of mercury (mmHg), blood glucose of 93 milligrams per deciliter (mg/dL), and BMI of 23.2 were all within normal parameters. He was not a smoker and met the U.S. Department of Health and Human Services (HHS) criteria for regular exercise (150–300 min/week moderate intensity or 75–150 min/week high intensity) [HHS 2019]. His total cholesterol was 215 mg/dL and his LDL (low density lipoprotein) was 148 mg/dL placing him in the borderline high category for both these parameters while his HDL (high density lipoprotein, i.e., protective or

54-Year-Old Interim Fire Captain Suffers Sudden Cardiac Event During Physical Ability Test—New Hampshire

“good cholesterol”) of 26 mg/dL was low. This overall lipid profile alone placed him at increased risk for atherosclerotic heart disease. Based on his age and risk factors, the American Cardiology Association/American Heart Association (ACC/AHA) Atherosclerotic Cardiovascular Disease (ASCVD) risk calculator indicated that the CAPT had a 6.5% 10-year risk of heart attack or stroke.

Discussion

Sudden Cardiac Events

Sudden cardiac events are most often caused by myocardial infarction (heart attack) or abnormal heart rhythms leading to cardiac arrest. In the United States, atherosclerotic coronary heart disease (coronary artery disease) is the most common risk factor for cardiac arrest and sudden cardiac death [Myerburg and Castellanos 2008]. Risk for the development of atherosclerosis is grouped into non-modifiable and modifiable risk factors. Non-modifiable risk factors include age older than 45, male sex, and family history of coronary artery disease. Modifiable risk factors include diabetes mellitus, smoking, high blood pressure (hypertension), unhealthy blood cholesterol levels, and obesity/physical inactivity [ACC/AHA 2018].

Coronary Artery Disease

Coronary artery disease (CAD) refers to atherosclerotic plaque in the coronary arteries and the complications of the plaque. The narrowing of the coronary arteries by atherosclerotic plaques occurs over many years, typically decades [Libby 2013]. Plaque buildup that restricts blood flow and prevents sufficient oxygen delivery to the myocardium causes ischemia and may result in chest pain (angina), particularly with exertion. Establishing the occurrence of an acute heart attack requires a medical evaluation that may find characteristic ECG changes, elevated cardiac enzymes, or imaging showing the blockage and/or ventricular wall motion abnormality (damaged heart muscle will not contract normally). The CAPT did not have a rhythm that allowed for the determination of a heart attack and he did not survive long enough for troponin levels to be elevated or imaging modalities to be used.

Evidence of myocardial damage from a heart attack may also be noted at autopsy. The autopsy did not reveal any thrombi reflecting an acute heart attack, however the autopsy did reveal areas of discoloration and fibrosis in the heart tissue that indicates the CAPT had had two prior heart attacks. Heart tissue that has been damaged by previous ischemia or infarcts is vulnerable to arrhythmias that can be fatal, particularly when the heart is working hard. Ischemia is defined as an inadequate blood supply to an organ or tissue. This can occur with exertion when the heart requires more oxygen to meet the increased work demand, such as during the CPAT. If the blood flow carrying the needed oxygen cannot increase enough to meet the increased demand due to atherosclerotic plaque blocking the inside of the blood vessels that supply the heart, then ischemia occurs. The autopsy showed that the CAPT had atherosclerotic blockages in three main coronary arteries that were severe enough to result in almost total occlusion of blood flow. Intraplaque hemorrhage refers to the rupture of a blood vessel within a complicated plaque and is associated with an increased risk of future cardiac events [Takaya et al. 2006].

Dyslipidemia

The accumulation of cholesterol and complicated atherosclerotic plaque in the arterial wall and the associated inflammation are hallmarks of coronary artery disease. The Framingham study [Mahmood

54-Year-Old Interim Fire Captain Suffers Sudden Cardiac Event During Physical Ability Test—New Hampshire

et al. 2014] and other large epidemiological research studies [Huxley et al. 2002; Stamler et al. 2008] have established that blood lipids are important predictors of coronary artery disease and of sudden cardiac death. Although the CAPT was normal weight and exercised regularly he had borderline high cholesterol and low-density lipoproteins (bad cholesterol), low HDL (good cholesterol), and elevated blood fats (hypertriglyceridemia).

NIOSH offers the following recommendations to help reduce the risk of sudden cardiac events among firefighters at this and other fire departments across the country.

Recommendations

Recommendation #1: Phase in a comprehensive wellness and fitness program for firefighters.

Discussion: 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* [NFPA 2015], and *The Fire Service Joint Labor Management Wellness-Fitness Initiative Candidate Physical Ability Test 2nd Edition* [IAFF 2007]. 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 workdays [Aldana 2001; Stein et al. 2000]. Health promotion programs for firefighters have been shown to reduce coronary heart disease risk factors and improve fitness levels, with mandatory programs showing the most benefit [Blevins et al. 2006; Dempsey et al. 2002; Womack et al. 2005].

Recommendation #2: Consider requiring medical evaluations for rehires take place (a) within 3–6 months of the pre-/rehire date and (b) before the candidate is allowed to take the pre-/rehire CPAT.

Discussion: Medical conditions and their risk factors can arise and/or change over time. A rehire candidate's medical condition needs to be assessed closer to the rehire date to ensure they remain in good health to start work safely. Especially in such a physically demanding job, this medical evaluation should also include assessment of cardiovascular risk factors. Ideally the medical evaluation should occur just prior to taking the physically demanding CPAT to identify candidates with possible underlying CAD and/or pre-existing risk factors for sudden cardiac events that may surface as a result of engaging in this strenuous exercise. Candidates noted to have an increased risk should be referred for the appropriate cardiac assessment and subsequent management to reduce their risk of adverse cardiac events associated with taking the CPAT and engaging in the rigorous physical activity they will be expected to do once rehired [Smith et al. 2020; Soteriades et al. 2011].

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54-Year-Old Interim Fire Captain Suffers Sudden Cardiac Event During Physical Ability Test—New Hampshire

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54-Year-Old Interim Fire Captain Suffers Sudden Cardiac Event During Physical Ability Test—New Hampshire

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Investigator Information

This incident was investigated by the NIOSH Fire Fighter Fatality Investigation and Prevention Program, Cardiac and Medical Line-of-Duty Deaths (LODD) Investigations Team, located in Cincinnati, Ohio. Denise L. Smith, Ph.D., led the investigation and authored the report. Dr. Smith is Professor of Health and Human Physiological Sciences, and Director of the First Responder Health and Safety Laboratory at Skidmore College, where she holds the Tisch Family Distinguished Professorship. She is also a member of the NFPA Technical Committee on Occupational Safety and Health. Dr. Smith was working as a contractor with the NIOSH Fire Fighter Fatality Investigation and Prevention Program, Cardiac and Medical LODD Investigations Team, during this investigation.

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