



Fire Fighter Suffers Fatal Heart Attack While Performing Physical Fitness Training - Missouri

SUMMARY

On January 21, 2003, at approximately 2045 hours, a 50-year-old male career Captain was lifting weights and walking on a treadmill in his fire station's exercise room when he experienced chest pains. After alerting his crew members, medical treatment for angina was begun. When his chest pain persisted and he became increasingly ill, he was loaded into an ambulance and transported to the hospital by in-house ambulance personnel. Despite being given advance life support (ALS) in the ambulance, he went into cardiac arrest and cardiopulmonary resuscitation (CPR) was begun. ALS measures were continued inside the emergency department (ED) for 18 minutes until he was pronounced dead and resuscitation measures were stopped. The death certificate listed "acute myocardial infarction" due to "atherosclerotic coronary artery disease" as the immediate cause of death. The autopsy listed "coronary atherosclerosis" followed by "stenosis, thrombosis, chronic myocardial infarct, subacute myocardial infarcts, acute myocardial infarct, and acute ischemic change" as the cause(s) of death.

The following recommendations address some general health and safety issues. This list includes some preventive measures that have been recommended by other agencies to reduce the risk of on-the-job heart attacks and sudden cardiac arrest among fire fighters. These selected recommendations have not been evaluated by NIOSH, but represent published research, or consensus votes of technical committees of the National Fire Protection Association (NFPA) or fire service labor/management groups.

- **Ensure that fire fighters are cleared for duty by a physician knowledgeable about the**

physical demands of fire fighting and the various components of NFPA 1582

Although unrelated to this fatality, the Fire Department should consider these additional recommendations based on safety and economic considerations:

- **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**
- **Consider incorporating exercise stress tests into the Fire Department's medical evaluation program**
- **Provide fire fighters with medical evaluations and clearance to wear SCBA**
- **Phase in a mandatory wellness/fitness program for fire fighters to reduce risk factors for cardiovascular disease and improve cardiovascular capacity**

The **Fire Fighter Fatality Investigation and Prevention Program** is conducted by the National Institute for Occupational Safety and Health (NIOSH). The purpose of the program is to determine factors that cause or contribute to fire fighter deaths suffered in the line of duty. Identification of causal and contributing factors enable researchers and safety specialists to develop strategies for preventing future similar incidents. The program does not seek to determine fault or place blame on fire departments or individual fire fighters. To request additional copies of this report (specify the case number shown in the shield above), other fatality investigation reports, or further information, visit the Program Website at

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Fire Fighter Suffers Fatal Heart Attack While Performing Physical Fitness Training - Missouri

- ***Perform an annual physical performance (physical ability) evaluation***
 - ***Discontinue lumbar spine x-rays as a screening test administered during the pre-placement medical evaluation***
- Autopsy record
 - Past medical records of the deceased

INTRODUCTION & METHODS

On January 21, 2003, a 50-year-old male Captain was lifting weights and walking on a treadmill as part of the Fire Department's voluntary physical fitness program when he began to suffer chest pains. After alerting his crew members, he was treated and transported to the hospital. While enroute, he suffered a cardiac arrest. Despite ALS and CPR performed by crew members in the ambulance and hospital personnel inside the ED, the victim died. NIOSH was notified of this fatality on January 22, 2003, by the United States Fire Administration. NIOSH contacted the affected Fire Department on January 27, 2003, to obtain further information and on July 18, 2003, to initiate the investigation. On July 28, 2003, a Safety and Occupational Health Specialist from the NIOSH Fire Fighter Fatality Investigation Team traveled to Missouri to conduct an on-site investigation of the incident.

During the investigation NIOSH personnel interviewed:

- The Fire Chief
- The Captain's crew members
- The Captain's wife

During the site-visit NIOSH personnel reviewed:

- Fire Department policies and operating guidelines
- Fire Department training records
- The Fire Department annual report for 2002
- Fire Department incident report
- Fire Department physical examination protocols
- Fire Department medical records
- Death certificate

INVESTIGATIVE RESULTS

On January 21, 2003, the Captain reported for duty at his fire station (Station 1) at 0630 hours. He was the assigned officer on Engine 2015. During the shift, Engine 2015 was dispatched to only one alarm: a medical call for difficulty breathing at 0914 hours. Engine 2015 returned to service at 0933 hours. The remainder of the day was spent teaching a driver's training class and performing administrative tasks.

At approximately 1730 hours, the Captain ate dinner with the crew. At approximately 2000 hours, he telephoned his wife. During that conversation he never reported any distress or any type of chest discomfort. At approximately 2015 hours, he went to the exercise room on the second floor to lift weights and walk on the treadmill. At 2046 hours, he left the exercise room and advised his crew members that he was not feeling well. Crew members led him to a chair, and, after sitting down, he vomited several times. Dispatch was notified while crew members began to evaluate him and retrieve medical equipment.

The Captain had rapid, labored breathing, increased blood pressure, and his skin was wet (from sweating), pale, and hot. A cardiac monitor revealed sinus tachycardia. (These are, however, common manifestations of heavy exercise). He stated he would be more comfortable if he could lay on the floor. After being assisted to the floor, he was given two doses of sublingual nitroglycerin, two aspirin, and 100% oxygen (via non-rebreather mask). His first mention of pain did not subside and he was loaded onto a stretcher and taken to the ambulance (EMS 2017) located inside his fire station. Prior to departing for the hospital at 2101 hours, he vomited several more times.



Fire Fighter Suffers Fatal Heart Attack While Performing Physical Fitness Training - Missouri

Enroute, intravenous access was gained and ALS medications were administered. The Captain's chest pain was described as "10/10, radiating to his mid-back, continuous, and sharp with no relief." He appeared to become more anxious. Just prior to arrival at the hospital, at 2111 hours, his condition deteriorated. He presented with decorticate posturing (abnormal posturing exemplified by rigidity, flexion of the arms, clenched fists, and extended legs), purple colored head and neck, clinched teeth and grips, and loss of airway with no respirations. He became unresponsive, apneic, and pulseless. Artificial respirations were begun via bag-valve-mask (confirmed by witnessing chest rise/fall). The cardiac monitor revealed ventricular fibrillation (V.fib.), one shock was administered, and the Captain's heart rhythm reverted to pulseless electrical activity. The ambulance arrived at the hospital at 2112 hours. Inside the ED, his heart rhythm changed from asystole to V.fib. and he was shocked an additional five times with no improvement. Resuscitation efforts continued until 2130 hours when he was pronounced dead and resuscitation measures were discontinued.

Medical Findings. The death certificate, completed by the Medical Examiner, listed "Acute myocardial infarction" due to "atherosclerotic coronary artery disease" as the immediate cause of death. Since the Captain was not involved in any fire suppression duties that day, a carboxyhemoglobin level (a measure of exposure to carbon monoxide) was not checked. Pertinent findings from the autopsy, performed by a private physician, on January 22, 2003, included:

- A large heart (435 grams with normal less than 400 grams)
- Significant coronary atherosclerosis
- Stent placement in three coronary arteries [left anterior descending (LAD), left circumflex, right coronary artery]
- Evidence of old heart attacks (myocardial infarcts or MIs)

- Left ventricular free wall (both subendocardial and transmural) fibrosis
- Interventricular septum
- Subacute MIs
- Acute (recent) MI in the interventricular septum and left ventricular free wall as evidenced by:
 - Ischemic changes
 - Complete occlusion of the LAD stent with a blood clot (thrombus)

In 1991, the Captain began experiencing intermittent palpitations (fast heart beats). Medical evaluation consisted of an EKG which revealed frequent premature ventricular contractions (PVCs) - a type of heart arrhythmia. To evaluate the possibility that coronary artery disease (CAD) was responsible for this arrhythmia, the Captain had a thallium exercise stress test (EST). During the EST the Captain exercised for 11 minutes, 40 seconds reaching Stage 4 of the Bruce Protocol [12.5-13 metabolic equivalents (METs)]. His heart rate exceeded its target of 170 beats per minute. He had a good blood pressure response, no chest pain, no ischemic changes on the EKG or the thallium scan, however, his PVCs (unifocal) did increase to approximately 30 per minute. This resulted in an echocardiogram which showed a slightly myxomatous degeneration of the mitral valve (no actual prolapse), with normal left ventricular systolic function with no regional wall motion abnormalities to suggest underlying CAD. These negative studies concluded that his PVCs did not need any additional work-up. However, his palpitations continued and in 1993 and 1995 his EST were repeated. During both tests he exercised for more than ten minutes reaching Stage 4 of the Bruce Protocol and achieved his target heart rate. Both EST were negative for signs of ischemia (no chest pain, no EKG ST segment changes, good blood pressure response) and his baseline PVCs actually decreased in frequency during exercise.



Fire Fighter Suffers Fatal Heart Attack While Performing Physical Fitness Training - Missouri

In the fall of 2001, the Captain had some atypical chest pain that was subsequently evaluated by an echocardiogram EST. This test was positive for ischemia (reversible areas of hypokinesis in the anteroseptal segments). He underwent a cardiac catheterization in October 2001 which showed 90% stenosis of his left anterior descending (LAD) artery which was opened via angioplasty and stent placement (two stents in his LAD). Two months later he had a repeat EST which showed reversible anterior ischemia and a depressed ejection fraction of 46%. Two days later a cardiac catheterization showed a normal left ventricular ejection fraction (65%), mild to moderate blockage of the stents (40-50% in-stent restenosis), and no other significant blockage. He was released to return to work by his cardiologist in January 2002.

The Captain continued to have episodic atypical chest pain and a thallium EST in May 2002 showed a moderate size anteroseptal apical reversible defect. He underwent another cardiac catheterization which showed two areas of focal high-grade (60-80%) blockage in the LAD stents. In addition, his right coronary artery (RCA) had developed a new 75-80% blockage in its mid-portion. The RCA was opened with angioplasty and stent placement, while the LAD restenosis was successfully treated with intravascular radiation. He was cleared for return to work in June by his cardiologist.

A follow-up thallium EST in November 2002, showed a new reversible anterolateral defect. A subsequent cardiac catheterization showed a new, 80% blockage, of the left circumflex coronary artery and a left ventricular ejection fraction of 60%. Like his two previous blockages, this new circumflex lesion was opened via angioplasty and stent placement. He was cleared for return to work by his cardiologist in December 2002 with a follow-up thallium EST scheduled for March 2003.

According to his wife and crew members, immediately prior to this incident, the Captain had no complaints of chest pains or any symptoms suggestive of acute heart-related problems.

DESCRIPTION OF THE FIRE DEPARTMENT

At the time of the NIOSH investigation, this career Fire Department consisted of 38 uniformed personnel. The Department served a population of 23,000 in an area of 5.9 square miles. There are two fire stations. The FD also provides ALS medical service. Fire fighters work the following schedule: 24 hours on-duty, 24 hours off-duty, 0630 hours to 0630 hours, for three tours, then are off-duty for four days.

In 2002, the Department responded to 2,956 calls: 37 structure fires, 46 vehicle fires, 21 brush/grass fires, 7 trash/rubbish fires, 93 hazardous condition calls, 52 smoke scare calls, 67 system malfunction calls, 92 false alarms, 95 other miscellaneous calls, 1274 emergency medical calls, 93 rescue calls, and 1079 mutual aid calls.

Training. The Fire Department requires all new fire fighter applicants to be State-certified as a Fire Fighter I and II and Paramedic, pass a written test (ranked by score), and an oral interview prior to being hired contingent on passing: 1) a pre-placement physical exam, 2) a psychological examination, and 3) a drug screen performed by a City-contracted physician. A Paramedic without State certification as a Fire Fighter I and II may be hired, but is sent to the 10-week County Fire Academy within six months of being hired to become certified as a Fire Fighter I and II. At the County Fire Academy, the candidate must present a physician's clearance prior to taking a physical agility test (discussed below).



Fire Fighter Suffers Fatal Heart Attack While Performing Physical Fitness Training - Missouri

The physical agility test consists of the following timed events while wearing full turnout gear and self-contained breathing apparatus:

- Advance uncharged 1¾-inch fire hose with nozzle a distance of 200 feet
- Using a 9-pound soft impact sledgehammer to move an exercise/kaiser sled ram 5 feet in each direction
- Carry two high rise packs of 1½-inch fire hose up and down two flights of stairs
- Remove a 16-foot ladder from a rack, carry it 10 feet, then replace it on its original position on an identical rack
- Proceed on hands and knees on rafters, spaced 24-inches apart, through a ground level attic prop
- Drag a 140-pound sandbag 120 feet backward

Recurrent training occurs daily on each shift. The State minimum requirements for fire fighter certification are Fire Fighter I and II. There is no State requirement for fire fighter recertification. The Captain was certified as a Fire Fighter I and II, Driver/Operator, EMT-P, Hazardous Materials Operations level, and Fire Officer I. He had 26 years of fire fighting experience.

Pre-placement Evaluations. The FD requires a pre-placement medical evaluation for all fire fighter candidates, regardless of age. Components of the evaluation include:

- A complete medical history
- Physical examination
- Vital signs
- Vision screening
- Hearing (whisper) test
- Audiogram
- Blood analysis (non-specific)
- Urinalysis dipstick
- Chest x-ray
- Electrocardiogram (EKG)
- Lumbar spine x-ray
- Pulmonary Function Test

These evaluations are performed by a contract physician hired by the City, who then makes a decision regarding medical clearance for fire fighting duties. This decision is forwarded to the City Human Resources Director.

Periodic Evaluations. Periodic medical evaluations are not required by this Department.

Fire fighters may elect to undergo a general health screening and physical fitness program administered by a local contract health center. Components of this screening include the following:

- A complete medical history
- Coronary risk profile
- Cholesterol fractionation
- Glucose level
- Fitness profile
- Nutrition profile
- Lung function profile (spirometry)
- Vital signs, and
- Body mass index calculation

If the screening identifies any health problems, the fire fighter is advised to see their personal physician. The Captain had his last FD fitness/wellness evaluation in March 2002. He exercised for 5 minutes on the Gerkin Protocol achieving his target heart rate (161 beats per minute) and a VO₂ max of 39.55 milliliters per kilogram per minute (ml/kg/min).

All fire fighters are fit tested annually to wear SCBA, but medical clearance for respirator use is not required.

If an employee is injured at work, or is ill and off work for more than three consecutive shifts, the employee is evaluated by their personal physician, who forwards their recommendation regarding “return to work” to the City contract physician, who makes the final determination. While the Captain was last cleared for return to work by his cardiologist in 2002,



Fire Fighter Suffers Fatal Heart Attack While Performing Physical Fitness Training - Missouri

there was no documentation to determine if the City contract physician cleared him.

Exercise (strength and aerobic) equipment is located in the fire stations. Voluntary wellness/fitness programs are in place for the Department, however the type of exercise performed is left to the individual fire fighter. Additionally, reduced rate memberships to a local health club are available. Most fire fighters participate in these fitness activities while on duty. Health maintenance information is available from the City.

The Captain exercised regularly by walking on a treadmill and lifting weights.

DISCUSSION

In the United States, coronary artery disease (atherosclerosis) is the most common risk factor for cardiac arrest and sudden cardiac death.¹ Risk factors for its development include age over 45, male gender, family history of coronary artery disease, smoking, high blood pressure, high blood cholesterol, obesity/physical inactivity, and diabetes.^{2,3} The victim had known CAD plus four of these risk factors (age over 45, male gender, high blood cholesterol, and overweight).

The narrowing of the coronary arteries by atherosclerotic plaques occurs over many years, typically decades.⁴ However, the growth of these plaques probably occurs in a nonlinear, often abrupt fashion.⁵ 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.⁶ This sudden blockage is primarily due to blood clots (thrombosis) forming on the top of atherosclerotic plaques. The victim had a blood clot in one of his LAD stents at autopsy and he had severe coronary atherosclerotic disease.

Firefighting is widely acknowledged to be one of the most physically demanding and hazardous of all civilian occupations.⁷ Firefighting activities are strenuous and often require fire fighters to work at near maximal heart rates for long periods. The increase in heart rate has been shown to begin with responding to the initial alarm and persist through the course of fire suppression activities.⁸⁻¹⁰ 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.¹¹ Epidemiologic studies have found that heavy physical exertion sometimes immediately precedes and triggers the onset of acute heart attacks.¹²⁻¹⁵ While exercising, the victim lifted weights and walked on a treadmill at a fast pace. This is considered a heavy level of physical exertion.¹⁶ The physical stress of performing heavy exercise and his underlying atherosclerotic CAD contributed to this fire fighter's heart attack, subsequent cardiac arrest, and sudden death.

To reduce the risk of heart attacks and sudden cardiac arrest among fire fighters, the NFPA has developed guidelines entitled "Standard on Medical Requirements for Fire Fighters and Information for Fire Department Physicians," otherwise known as NFPA 1582.¹⁷ NFPA 1582 recommends a yearly physical evaluation to include a medical history, height, weight, blood pressure, and visual acuity test.¹⁷ NFPA 1582 also recommends a thorough examination to include vision testing, audiometry, pulmonary function testing, a complete blood count, urinalysis, and biochemical (blood) test battery be conducted on a periodic basis according to the age of the fire fighter (less than 30: every 3 years; 30-39: every 2 years; over 40 years: every year). The Department requires a pre-placement medical examination for all new hires but does not require periodic medical evaluations.



Fire Fighter Suffers Fatal Heart Attack While Performing Physical Fitness Training - Missouri

Since the victim had several CAD risk factors, including known CAD, several EST were performed between 1991 and 2002. The EST performed in October and December 2001, and May and December 2002 showed persistent new ischemia. NFPA 1582 lists “coronary artery disease...or coronary angioplasty...” as a Category B condition, which is defined as “a medical condition that, based on its severity or degree, 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 1582 Appendix A, while included for informational purposes only and is not a part of the requirements of NFPA 1582, states the presence of “exercise-induced ischemia by exercise testing” would be a disqualifying condition.¹⁷ Although the Captain had therapeutic procedures for these EST ischemia, he should have been on restrictive duty until an EST revealed no ischemic changes.

RECOMMENDATIONS

The following recommendations address health and safety generally. This list includes some preventive measures that have been recommended by other agencies to reduce the risk of on-the-job heart attacks and sudden cardiac arrest among fire fighters. These recommendations have not been evaluated by NIOSH, but represent published research, or consensus votes of technical committees of the NFPA or fire service labor/ management groups.

Recommendation #1: Ensure that fire fighters are cleared for duty by a physician knowledgeable about the physical demands of fire fighting and the various components of NFPA 1582.

Physicians providing input regarding medical clearance for fire fighting duties should be knowledgeable about the physical demands of fire

fighting and familiar with the consensus guidelines published by NFPA 1582.¹⁷ The “return to work” decision requires knowledge not only of the employee’s medical condition, but also of the employee’s job duties. Although the City contract physician is aware of essential job tasks and NFPA 1582, many private physicians are not. Therefore, NIOSH recommends that the FD/City not automatically accept the opinion of the employees private physician regarding return to work and consider having all return to work clearances reviewed by the City’s contractor. Thus, the final decision regarding medical clearance for return to work lies with the City/FD with input from many sources including the employees private physician. While the requirement exists, there is no evidence that the Captain’s return to work was cleared by the City contract physician. He was cleared by his cardiologist.

Recommendation #2: Provide mandatory annual medical evaluations to ALL fire fighters to determine their medical ability to perform duties without presenting a significant risk to the safety and health of themselves or others.

This finding did not contribute to the death of this fire fighter, but was identified by NIOSH during the investigation. Guidance regarding the content and frequency of periodic medical evaluations and examinations for fire fighters can be found in NFPA 1582, Standard on Medical Requirements for Fire Fighters and Information for Fire Department Physicians,¹⁷ and in the report of the International Association of Fire Fighters/International Association of Fire Chiefs (IAFF/IAFC) wellness/fitness initiative.¹⁸ The Department is not legally required to follow any of these standards. Nonetheless, we recommend the City and Union **work together** to establish the content and frequency in order to be consistent with the above guidelines.



Fire Fighter Suffers Fatal Heart Attack While Performing Physical Fitness Training - Missouri

The success of medical programs hinges on protecting the affected fire fighter. The Department must **1)** keep the medical records confidential, **2)** provide alternate duty positions for fire fighters in rehabilitation programs, and **3)** if the fire fighter is not medically qualified to return to active fire fighting duties, provide permanent alternate duty positions or other supportive and/or compensated alternatives.

Recommendation #3: Consider incorporating exercise stress tests into the Fire Department's medical evaluation program.

This finding did not contribute to the death of this fire fighter, but was identified by NIOSH during the investigation. NFPA 1582 and the IAFF/IAFC wellness/fitness initiative both recommend at least biannual EST for fire fighters.^{17,18} They recommend that these tests begin at age 35 for those with CAD risk factors, and at age 40 for those without CAD risk factors. The EST could be conducted by the fire fighter's personal physician, the City physician, or the Department's contract physician. If the fire fighter's personal physician or the contracted 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 #4: Provide fire fighters with medical evaluations and clearance to wear SCBA.

This finding did not contribute to the death of this fire fighter, but was identified by NIOSH during the investigation. OSHA's Revised Respiratory Protection Standard requires employers to provide medical evaluations and clearance for employees using respiratory protection.¹⁹ Such employees include fire fighters who utilize 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. Missouri is not a State-plan state, therefore, public sector employers are not required to comply with OSHA standards. However, we recommend voluntary compliance and a copy of the OSHA medical checklist has been provided to the Fire Department.

Recommendation #5: Phase in a mandatory wellness/fitness program for fire fighters to reduce risk factors for cardiovascular disease and improve cardiovascular capacity.

This finding did not contribute to the death of this fire fighter, but was identified by NIOSH during the investigation. Physical inactivity is the most prevalent modifiable risk factor for CAD in the United States. Additionally, physical inactivity, or lack of exercise, is associated with other risk factors, namely obesity and diabetes.²⁰ NFPA 1500, Standard on Fire Department Occupational Safety and Health Program, requires a wellness program that provides health promotion activities for preventing health problems and enhancing overall well-being.²¹ NFPA 1583, Standard on Health-Related Fitness Programs for Fire Fighters, provides the minimum requirements for a health-related fitness program.²² In 1997, the International Association of Fire Fighters (IAFF) and the International Association of Fire Chiefs (IAFC) published a comprehensive Fire Service Joint Labor Management Wellness/Fitness Initiative to improve fire fighter quality of life and maintain physical and mental capabilities of fire fighters. Ten fire departments across the United States joined this effort to pool information about their physical fitness programs and to create a practical fire service program. They produced a manual and a video detailing elements of such a program.¹⁸ The Fire Department and the Union should review these materials to identify applicable elements for their Department. Other large-city negotiated programs can also be reviewed as potential models. Wellness

Fire Fighter Suffers Fatal Heart Attack While Performing Physical Fitness Training - Missouri

programs have been shown to be cost effective, typically by reducing the number of work-related injuries and lost work days.²³⁻²⁵ A similar cost savings has been reported by the wellness program at the Phoenix Fire Department, where a 12-year commitment has resulted in a significant reduction in their disability pension costs.²⁶

Recommendation #6: Perform an annual physical performance (physical ability) evaluation.

NFPA 1500 requires fire department members who engage in emergency operations to be annually evaluated and certified by the fire department as meeting the physical performance requirements identified in paragraph 8-2.1.²¹

Recommendation #7: Discontinue lumbar spine x-rays as a screening test administered during the pre-placement medical evaluation.

This finding did not contribute to the death of this fire fighter, but was identified by NIOSH during the investigation. The FD currently performs pre-placement physical evaluations, which include routine lumbar spine X-rays. While these X-rays may be useful in the evaluation of individuals with existing problems, the American College of Radiology, American College of Occupational and Environmental Medicine, and NIOSH all have concluded that lumbar spine X-rays have no value as a routine screening measure to determine those at risk for back injuries.²⁷⁻²⁹ This procedure involves both an unnecessary radiation exposure for the applicant and an unnecessary expense for the Department.

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Fire Fighter Suffers Fatal Heart Attack While Performing Physical Fitness Training - Missouri

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*Fire Fighter Suffers Fatal Heart Attack While Performing Physical Fitness Training -
Missouri*

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