



Fire Fighter Collapses and Dies Due to a Cardiac Arrest at a Training Exercise - Indiana

SUMMARY

On April 1, 1998, a 34-year-old male Safety Officer was participating in a live-burn training exercise. Seconds after the training fire was lit, the Safety Officer complained of shortness of breath and exited the house. Once outside, he used an inhaler that he carried for asthma attacks, but its use did not improve his symptoms. A nearby fire fighter placed a self-contained breathing apparatus (SCBA) mask with flowing air over the Officer's face to assist his breathing. A few seconds later, the Safety Officer collapsed, and fire fighters initiated CPR. Seven minutes later, an ambulance arrived on scene with four emergency medical technicians (EMTs) who took over resuscitation efforts. The Officer was again found to be without a pulse and respirations. An automatic external defibrillator (AED) was applied to the Officer's chest, but a shock was not advised. He had a "combi-tube" inserted to provide ventilation, and then he was transported to the nearest hospital.

Upon arrival at the local hospital's emergency department, the Officer was again found to be in full cardiac arrest and advanced life support (ALS) measures were instituted. After approximately 30 minutes of ALS in the emergency department, he regained a cardiac rhythm but was not able to maintain an adequate blood pressure. An electrocardiogram (EKG) at that time showed ischemic changes, and blood tests showed a normal blood count. Arrangements were then made for transfer to a tertiary care medical center.

Care provided at the tertiary care medical center somewhat stabilized his cardiovascular status, but anoxic (without oxygen) brain damage had already occurred. On April 2, 1998, 12 hours after his collapse, life support machines were disconnected,

and shortly thereafter, he died. The death certificate, completed by the county Deputy Coroner after an autopsy was performed, listed the immediate cause of death due to "(A) gastric (stomach) hemorrhage with shock, due to (B) gastro-arterial fistula, due to (C) Dieulafoy's lesion." "Arteriosclerotic and hypertensive heart disease" were listed as "other significant conditions contributing to death." The Deputy Coroner did not have access to the clinical and laboratory data from the medical centers involved with his resuscitation efforts. Specifically, blood counts on three different occasions, done by two different hospital laboratories, with two of the blood samples being taken after the Officer had received significant intravenous (IV) fluid (hydration), were normal. Subsequent discussions with the Deputy Coroner regarding this clinical data resulted in our agreement that this victim's immediate cause of death was a cardiac event with the gastric hemorrhage as another significant condition.

The following recommendations address some general health and safety issues. It is unlikely, however, that any of these recommendations could

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. 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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have prevented the sudden cardiac arrest and subsequent death of this fire fighter. 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 research presented in the literature or of consensus votes of technical committees of the National Fire Protection Association (NFPA) or labor/management groups within the fire service. In addition, the recommendations are presented in a logical programmatic order and are not listed in a priority manner.

- ***Consider equipping fire department apparatus with AEDs.***
- ***Fire fighters should have annual medical evaluations 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.***
- ***Provide fire fighters with medical evaluations and clearance to wear SCBA.***
- ***Reduce risk factors for cardiovascular disease and improve cardiovascular capacity by offering a wellness/fitness program for fire fighters.***

INTRODUCTION & METHODS

On April 1, 1998, a 34-year-old male Safety Officer collapsed and lost consciousness at a training exercise. Despite CPR and ALS administered by the fire fighters, EMTs, local hospital emergency department personnel, and tertiary care medical center personnel, the victim died on April 2, 1998. NIOSH was notified of this fatality on April 6, 1998, by the United States Fire Administration. On

October 14, 1998, NIOSH telephoned the affected Fire Department to initiate the investigation. On October 19, 1998, a Senior Medical Officer and a Safety and Occupational Health Specialist from the NIOSH Fire Fighter Fatality Investigation Team traveled to Indiana to conduct an on-site investigation of the incident.

During the investigation NIOSH personnel met with the

- Fire Chief
- Fire Department personnel involved in this incident
- Family members
- Training Officer
- Ambulance personnel

During the site visit NIOSH personnel also reviewed the

- Existing Fire Department investigative records, including coworker statements, dispatch records, and the victim's medical evaluations conducted for the fire department
- Fire Department policies and operating procedures
- Fire Department training records
- Fire Department annual report for 1997
- Past medical records of the deceased
- Local hospital's emergency department records of the resuscitation effort
- Tertiary medical center's medical records of the deceased
- Autopsy results and death certificate of the deceased

NIOSH personnel also contacted the pathologist (Deputy Coroner) who performed the autopsy.

INVESTIGATIVE RESULTS

Training Exercise. On April 1, 1998, at 1755 hours, a live-fire training exercise was initiated at a vacant house scheduled for demolition. Ten fire fighters were

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on scene including the Chief, Assistant Chief, and Safety Officer (the victim). At that point the Safety Officer was wearing his full turnout gear but no SCBA. The Fire Chief and the Safety Officer entered the house to light combustible materials used to initiate the training exercise. Just seconds after the fire was lit, the Safety Officer complained of shortness of breath, and the Chief advised him to exit the structure. Once outside, the Safety Officer went to his knees and used an inhaler (Primatene) which he carried for treatment of his asthma. The inhaler did not improve his symptoms. Other fire fighters, noting his situation, placed an SCBA mask with flowing air over the Safety Officer's face. They notified the Chief, who radioed dispatch at 1835 hours to request an ambulance for a subject with difficulty breathing. The Chief extinguished the training fire. Approximately 60 seconds later, the Safety Officer was not responding to questions, and fire fighters trained in CPR removed the SCBA mask covering his face. They noted his cyanotic appearance and the absence of a pulse or respirations. They initiated CPR as the Chief radioed dispatch at 1836 hours for a life-threatening condition with CPR in progress. At this point the victim began vomiting a whitish-colored substance consistent with a meal (potato soup) consumed approximately 1 hour previously. The fire fighters at the scene were trained in CPR, and some were EMTs certified to use an AED, but none of the fire department apparatus (trucks) carried AEDs.

At 1842 hours the ambulance with four EMTs arrived on scene. They found the victim to be unconscious, without respirations or a pulse. An AED was used to assess the victim's heart rhythm. He was found to have no heart beat (asystole). Intubation was difficult due to the victim's vomiting and clenched teeth, but eventually a "combi-tube" was successfully inserted to ventilate and oxygenate the victim. CPR continued as fire fighters removed the victim's turnout gear and transferred him onto a backboard and then into the ambulance for transport

to the nearest hospital. The ambulance departed the scene and arrived at the hospital at 1906 hours.

Upon arrival at the local hospital's emergency department, the combi-tube was removed, the Officer was intubated, an IV line placed, and his cardiac status was reassessed. He was again found to have no heart beat (asystole), and ALS measures were instituted. After approximately 30 minutes of ALS in the emergency department, he regained a cardiac rhythm, but he was able to maintain only a minimal blood pressure. An EKG done at this time revealed ST segment depression in the precordial leads, suggesting either ischemia (reduced blood flow) to the anterior-lateral wall of the heart or an injury (heart attack) to the heart's posterior wall. A naso-gastric (NG) tube was inserted into the victim's stomach, and a relatively small amount of blood was recovered. This was attributed to the oral trauma during on-scene efforts to intubate the victim. A blood count taken at this time was normal (hematocrit = 40%). IV fluids and medications were given to support the victim's low blood pressure, and arrangements were made to transfer the Officer to a tertiary care medical center.

The victim arrived at the tertiary care medical center at 2119 hours. Initial assessment revealed an unresponsive man who had suffered anoxic (lack of oxygen) brain damage during the 1 hour of resuscitation measures before his heart was able to maintain a blood pressure. His rectal exam showed strongly guaiac-positive (test for blood) stool, and his NG tube returned blood, again thought to be secondary to the traumatic intubation. Subsequent care was able to somewhat stabilize his cardiovascular status. A repeat EKG showed an abnormal heart rhythm (incomplete right bundle branch block) and an improvement/resolution of the ST segment depression in the precordial leads, suggesting the victim did not have a heart attack. Blood tests showed an elevated muscle enzyme (CPK), but the cardiac portion (MB bands) was normal, which also

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suggests that the victim did not suffer a heart attack. Blood counts, taken at 2119 and 0440 hours, were normal (hematocrit = 44 and 42, respectively). On April 2, 1998, 12 hours after his collapse, due to his exceedingly grave prognosis, the life support machine was disconnected, and he died shortly thereafter.

Medical Findings. The death certificate was completed by the county Deputy Coroner after he had performed the autopsy. The immediate cause of death was listed as “(A) gastric hemorrhage with shock,” due to “(B) gastro-arterial fistula,” due to “(C) Dieulafoy’s lesion.” Arteriosclerotic and hypertensive heart disease were listed as significant conditions contributing to his death. The autopsy was significant for

Heart

- A large heart (540 grams) with symmetrical left ventricular hypertrophy
- Moderate atherosclerotic coronary artery disease:
 - 70% blockage of the left anterior descending coronary artery
 - 50% blockage of the right coronary artery
 - 40% blockage of the left circumflex coronary artery

Digestive System

- Two 1.0 centimeter linear erosions in the stomach. One erosion was ulcerated with an eroded blood vessel with a blood clot (thrombus). The small intestine and colon were filled with a red-brown bloody liquid (blood).

Blood tests for carboxyhemoglobin (a test that determines exposure to carbon monoxide, which is a major toxic constituent of fire smoke) were not conducted because he was exposed to little or no smoke at the training exercise. A blood alcohol and drug screen were negative. Medical records indicated that the victim had never complained of stomach problems or had episodes of stomach

bleeding. He did have a few risk factors for coronary artery disease (family history, male gender, high cholesterol, and obesity).

DESCRIPTION OF THE FIRE DEPARTMENT

At the time of the NIOSH investigation, the fire department was comprised of 28 volunteers in two stations and served a population of 3,700 in a geographic area of 25 square miles. The staffing levels preferred by the department would be 20 volunteers and 5 probationary fire fighters for each station. The main reason cited by the Fire Chief for not achieving this full complement of volunteer fire fighters is the training for fire fighters required by the State of Indiana and the time commitment. The department follows an Incident Command System such as that described by the NFPA 1561¹ and follows OSHA’s “2-in/2-out rule.”² In 1997, the department responded to 203 calls: 46 standby, 44 investigation only, 39 extinguishment, 37 not classified, 33 remove hazard, 3 rescue only, and 1 mutual aid.

Training. The fire department provides all new fire fighters with the basic 24-hour recruit training required by the State of Indiana. The department also conducts 24 hours of additional on-the-job training each year. The victim had 14 years of fire fighting experience, was a certified Fire Fighter Level II, and was promoted to Safety Officer in January 1998.

Medical Clearance and Physical Fitness. All volunteer fire fighters in this department must receive a preemployment medical evaluation. This evaluation is typically dovetailed into the medical evaluation done for the volunteer’s regular job. If the volunteer’s regular job does not require a medical evaluation, the department will cover the expenses incurred by the applicant for this evaluation. The required components of the department’s evaluation consist of a medical history, height, weight, pulse, blood

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pressure, physical examination of the heart, lungs, ears, nose, and throat. The physician must “clear” the fire fighter to perform fire fighting duties. Audiometry, visual acuity, or other laboratory tests are not required but can be ordered at the discretion of the examining physician. This medical evaluation is conducted every 2 years until the age of 45, when it is conducted annually. The victim had passed his annual medical evaluation approximately 9 months prior to his death. This evaluation was performed for his commercial driver’s license.

The department does not have a specific medical clearance evaluation for respirator use, nor does the department have a physical agility/fitness requirement for new or current fire fighters.

DISCUSSION

Dieulafoy’s disease is a distinctive blood vessel anomaly (arteriovenous malformation) in the gastrointestinal tract.³ The artery is frequently described as unusually large and tortuous at the base of an ulcer.⁴⁻⁶ It was first described in 1896 in the stomach (gastric fundus), and the stomach is its most common location.⁷ The incidence or prevalence of this disease is unknown, but the medical literature suggest it is under-diagnosed due to the difficulty in finding the lesion.⁸⁻¹⁰ Nonetheless, it is a rare condition but not an uncommon cause of massive, life-threatening upper gastrointestinal bleeding.⁹⁻¹³

This victim’s clinical presentation (cardiac arrest) was very unusual for Dieulafoy’s disease. Prior to his demise, he did not complain of stomach problems or have episodes of vomiting blood. Indeed, his vomitus was white, not bloody. Without any gastrointestinal symptoms, a diagnostic procedure such as endoscopy (direct visualization of the stomach lining) would not have been indicated in the days or weeks prior to this tragic event.

When the county Deputy Coroner performed the autopsy and completed the death certificate, he did not have access to the clinical and laboratory data from the medical centers involved with the victim’s resuscitation efforts. Critical data included

1. The victim’s vomitus (soon after he collapsed) did not contain blood.;
2. The relatively small amount of blood that returned on suctioning from his NG tube; and
3. Normal blood counts on three different occasions, done by two different hospital laboratories, with two of the blood specimens collected after the Officer had received significant IV fluid (hydration).

Subsequent discussions with the Deputy Coroner regarding this clinical data resulted in our agreement that this victim’s immediate cause of death was a cardiac event. The gastric hemorrhage (Dieulafoy’s disease) was a significant condition, but it probably did not trigger his cardiac event.

Another confusing issue regarding this death is the lack of evidence that the victim suffered an acute heart attack. Acute (recent) heart attacks are confirmed by one of the following: (1) blood tests finding elevated cardiac iso-enzymes (CPK-MB), (2) characteristic finding on EKG (ST segment elevation), and (3) on autopsy, thrombus (blood clot) formation in one of the coronary arteries. Although the victim had marked elevations of the muscle enzyme CPK (probably due to the multiple shocks administered during resuscitation efforts at the local medical center), the heart proportion of that enzyme was not elevated. This blood was collected approximately 4 hours after his collapse, within the time frame when, if a heart attack had occurred, the blood test should be elevated. On autopsy, a thrombus was not found; however, it is important to note that thrombus formation on autopsy is present in less than 50% of individuals dying from acute heart attacks. Finally, the victim’s EKGs were most consistent with ischemia, not injury, which improved

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or resolved when the second EKG was taken at the tertiary medical center.

These findings suggest the victim's collapse and cardiac arrest were probably related to a primary heart arrhythmia, not an arrhythmia associated with a heart attack. In addition, the autopsy noted an enlarged heart with symmetrical left ventricular hypertrophy. The most common cause for an enlarged heart (cardiomyopathy) is ischemic or hypertensive (chronic high blood pressure) heart disease.¹⁴ There was no evidence the victim had a remote or recent heart attack, and the victim was never diagnosed with high blood pressure during his numerous biannual physical examinations. This suggests a less common reason for his enlarged heart. Particularly intriguing is hypertrophic cardiomyopathy, which is associated with sudden death in young men.¹⁴ This condition, hypertrophic cardiomyopathy, is an hereditary disease (autosomal dominant) with genetic heterogeneity. Evidence against this diagnosis is the lack of characteristic histologic (microscopic) lesions in the heart muscle. It may never be conclusively determined that this victim had hypertrophic cardiomyopathy, but the family has been notified of this possibility. First-degree relatives (parents, brothers and sisters) and offspring (sons and daughters) should seek medical consultation regarding a screening EKG and echocardiogram to diagnose the condition since it is an inherited and treatable condition.¹⁴

RECOMMENDATIONS AND DISCUSSION

The following recommendations address some general health and safety issues. It is unlikely, however, that any of these recommendations could have prevented the sudden cardiac arrest and subsequent death of this fire fighter. 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 research presented in the literature or of consensus votes of Technical Committees of the National Fire Protection Association or labor/management groups within the fire service. In addition, the recommendations are presented in a logical programmatic order and are not listed in a priority manner.

Recommendation #1: Consider equipping fire department apparatus with automatic external defibrillators (AEDs).

Hypertrophic cardiomyopathy is associated with sudden death, typically from ventricular tachycardia (V.Tach) and ventricular fibrillation (V.Fib). These are "shockable" heart rhythms, which can be converted using shocks delivered by certified EMTs using AEDs. Since it took 7 minutes before the ambulance arrived on scene, it is possible this victim's heart rhythm had already experienced V.Tach and V.Fib and was in the asystole by the time the ambulance arrived. Perhaps if fire fighters had access to an AED at the time of his collapse, the outcome might have been different. In addition, many fire fighters in this fire department are asked to serve in a first responder capacity, and some are EMTs certified in the use of AEDs. Having this equipment available, with fire fighters trained in their use, could potentially save civilian and/or fire fighters' lives in the future.

Recommendation #2: Fire fighters should have annual medical evaluations 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 scheduling of periodic medical examinations for fire fighters can be found in *NFPA 1582, Standard on Medical Requirements for Fire Fighters*¹⁵ and a copy has been provided for your use. In addition to providing

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guidance on the frequency and content of the medical evaluation, NFPA 1582 provides guidance on medical requirements for persons performing fire fighting tasks. Applying this recommendation involves economic repercussions and may be particularly difficult for small volunteer fire departments, such as the one involved in this incident, to implement.

To overcome the financial obstacle, this Fire Department could urge new volunteers to get medical clearances from their private physicians prior to engaging in fire suppression activities. The recommended content of these evaluations is contained in NFPA 1582. The brief annual medical evaluations recommended by NFPA could be completed by the volunteer (medical and occupational history), and by EMT/paramedics already on staff (vital signs, height, weight, and visual acuity), and this information could be shared with a local physician, perhaps volunteering his or her time, to review this data and provide medical clearance (or further evaluation, if needed). The more extensive periodic medical examinations could be performed by a private physician at the fire fighter's expense, provided by a physician volunteer, or paid for by the Fire Department. Sharing the financial responsibility for these evaluations between volunteers, the Fire Department, and willing physician volunteers should reduce the negative impact to recruit and retain needed volunteers.

Recommendation #3. Provide fire fighters with medical evaluations and clearance to wear self-contained breathing apparatus (SCBA).

OSHA's revised respiratory protection standard requires employers to provide medical evaluations and clearance for employees using respiratory protection.² These clearance evaluations are required for private industry employees and public employees in States operating OSHA-approved State plans. Indiana is a State-plan State; therefore, public employees are required to comply with OSHA

standards. A copy of the OSHA medical checklist has been provided to the Fire Department and should not involve a financial burden to the Fire Department beyond that already required for the preemployment, biannual, or annual medical evaluation.

Recommendation #4: Reduce risk factors for cardiovascular disease and improve cardiovascular capacity by phasing in a mandatory wellness/fitness program for fire fighters.

NFPA 1500 requires a wellness program that provides health promotion activities for preventing health problems and enhancing overall well-being.¹⁶ In 1997, the International Association of Fire Fighters and the International Association of Fire Chiefs joined in 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 with a video detailing elements of such a program.¹⁷ Fire departments should review these materials to identify applicable elements for their department.

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