



Fire Fighter Suffers Heart Arrhythmia and Dies at Wildland Fire - Washington

SUMMARY

On June 18, 2001, a 28-year-old male volunteer fire fighter responded to a wildland fire involving 20 acres of grassland. The victim drove a tanker to the fire scene and stretched 150 feet of wildland fire hose before collapsing. Seeing him fall, crew members came to his assistance and found him unresponsive, with no pulse and no respirations. Cardiopulmonary resuscitation (CPR) was begun immediately, and an ambulance was requested. The ambulance arrived on the scene 11 minutes later. Approximately 1 hour later, despite CPR and advanced life support (ALS) administered on the scene and at the hospital, the victim died. The autopsy and death certificate, completed by the County Coroner, listed “probable cardiac dysrhythmia due to fibrosis of the conduction system of the heart” as the cause 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 they represent published research or consensus votes of technical committees of the National Fire Protection Association (NFPA) or fire service labor/management groups. However, it is unlikely that any of these recommendations could have prevented the unfortunate death of this fire fighter.

- ***Conduct mandatory preemployment medical evaluations consistent with NFPA 1582 to determine a candidate’s medical ability to perform duties without presenting a significant risk to the safety and health of themselves or others.***

- ***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.***
- ***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.***
- ***Follow provisions in the revised OSHA respiratory protection standard.***
- ***Incorporate exercise stress tests into the Fire Department’s medical evaluation program.***
- ***Phase in a mandatory wellness/fitness program for fire fighters to reduce risk factors for cardiovascular disease and improve cardiovascular capacity.***
- ***Provide automated external defibrillators on all fire apparatus.***

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 www.cdc.gov/niosh/firehome.html or call toll free 1-800-35-NIOSH



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INTRODUCTION AND METHODS

On June 18, 2001, a 27-year-old male fire fighter lost consciousness after stretching a hoseline at a 20-acre wildland fire. Despite CPR and ALS administered by crew members, the ambulance crew, and in the emergency department, the victim died. On October 30, 2001, NIOSH contacted the affected Fire Department to initiate the investigation. On November 13, 2001, a Safety and Occupational Health Specialist from the NIOSH Fire Fighter Fatality Investigation Team traveled to Washington to conduct an on-site investigation of the incident.

During the investigation NIOSH personnel interviewed the following:

- Fire Chief
- Safety Officer
- Victim's parents
- Victim's wife

During the site visit NIOSH personnel reviewed the following:

- Fire Department policies and operating guidelines
- Fire Department training records
- Emergency medical service (ambulance) incident report
- Hospital emergency department report
- Death certificate
- Autopsy report
- Past medical records of the deceased

INVESTIGATIVE RESULTS

Incident. On June 18, 2001, at 1342 hours, the involved Fire Department was dispatched to a wildland fire that was threatening a residence. The victim responded to his fire station in his privately owned vehicle (POV) to drive one of the tenders (tanker) to the scene. Two fire fighters responded in their POVs directly to the fire scene. See Table 1 for a timeline of the response.

The fire, approximately 5 miles from the fire station, was burning an approximate area of 12 acres of light, flashy fuel (grass) and moving rapidly in a northerly direction. See Photograph 1 and Photograph 2. No structures were endangered at this time. The fire would eventually spread to an area of 20 acres.

After arriving at his fire station, the victim prepared to drive Tender 598 (a 3,000-gallon tanker) to the fire scene. He departed his fire station at 1351 hours and arrived at the fire scene at 1356 hours.

Fire fighters began the initial attack (using forestry hoseline tactics) on the southern portion of the fire, directing their attack along the west flank of the fire. The fire attack progressed normally, and containment was soon being accomplished. Other fire-fighting crews proceeded east down the hill, extinguishing hot spots. Upon arrival at the fire scene, the victim retrieved a 150 foot section of forestry hose from Tender 598, connected it to a previously connected gated wye from Brush 585, and stretched the hoseline further down the hill. He was operating alone during this task, but other crew members were nearby.

After stretching and extending the forestry hose, the victim began to walk back uphill toward Tender 598. After walking approximately 100 feet, he stumbled. Nearby crew members saw him stumble and nearly fall and inquired if he was alright. He stood up again and began to continue up the hill. After taking a few more steps, he collapsed. Crew members, seeing him fall, ran to his aid.

Initial assessment by crew members found the Fire Fighter to be unresponsive, not breathing, and pulseless. CPR (chest compressions and assisted ventilations via mouth-to-mouth) began immediately. Brush 585, parked nearby, notified the Incident Commander, who notified dispatch at 1409 hours. Medic 421 (one Paramedic and one Emergency



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Medical Technician) was dispatched. A medical helicopter was requested at 1413 hours.

Medic 421 arrived on the scene at 1420 hours, finding the victim unresponsive, not breathing, and pulseless, with CPR in progress. A cardiac monitor was attached to the victim, revealing ventricular fibrillation (a heart rhythm unable to sustain life). A cardiac shock was immediately administered. The victim's heart rhythm reverted to asystole (no heartbeat). ALS measures, including intubation, assisted ventilations via bag-valve-mask, and intravenous therapy, were begun. The cardiac monitor again revealed ventricular fibrillation, and two additional shocks (total of three) were administered without change in patient status. The victim's heart rhythm again reverted to asystole, and CPR continued. The victim was then loaded onto a stretcher and placed into the ambulance, which began transport to a nearby hospital at 1439 hours and arrived at the hospital emergency department at 1454 hours. Inside the emergency department, a cardiac monitor revealed electromechanical dissociation. CPR and ALS measures continued until 1507 hours, when the victim was pronounced dead by the attending physician.

Medical Findings.

The death certificate was completed by the County Coroner, who listed "probable cardiac dysrhythmia due to fibrosis of the conduction system of the heart" as the immediate cause of death. Other significant conditions (conditions contributing to death but not resulting in the underlying cause given above) listed on the death certificate was "focal coronary arteriosclerosis." The carboxyhemoglobin level was less than 5%, suggesting that carbon monoxide poisoning was not responsible for his demise. His urine and blood drug screen was negative for illicit drugs and alcohol. Pertinent findings from the autopsy, also performed by the County Coroner, on June 18, 2001, included

- Fibrosis of the conduction system of the heart. Sinoatrial node showed a loss of myocytes and fibrosis on microscopic examination.
- Focal moderate to severe atherosclerosis of the proximate left anterior descending (LAD) coronary artery.
50-75% luminal narrowing of the LAD.
Focal areas of subendocardial hemorrhage on microscopic examination.
- Mild perivascular fibrosis with adjacent areas of myocyte hypertrophy of the left ventricle and interventricular septum.
- Possible dilated right ventricle.

The Fire Fighter had the following risk factors for coronary artery disease (CAD): male gender, mild obesity, and lack of exercise. The victim was not currently prescribed any medications. In June 2000, the victim saw a physician for right knee pain. The exam revealed a height of 5' 7", a weight of 201 pounds, and a blood pressure of 124/84. He was not under any restrictions for fire-fighting duties.

According to his wife, family members, and coworkers, the Fire Fighter did not express symptoms of chest pain, shortness of breath, ankle swelling or any other symptom indicative of a heart condition at any time preceding the incident.

DESCRIPTION OF THE FIRE DEPARTMENT

At the time of the NIOSH investigation, the combination Fire Department consisted of 4 career fire fighters and 140 volunteers and served a population of 18,000 in a geographic area of 550 square miles. There are 12 fire stations. Fire fighters work the following schedule: 13 hours on duty, 9 hours off duty, from 0800 hours to 2100 hours, for 4 days, then they are off duty for 4 days.



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Training. New career fire fighter applicants are hired based on the duties of their primary position (Fire Fighter/Mechanic, Fire Fighter/Inspector, Fire Fighter/Fabricator, or Fire Fighter/Secretary). Once hired, the fire fighter receives training in search and rescue, live-fire, apparatus driving, pumper operations, emergency vehicle accident prevention, SCBA, and first aid. Fire fighters receive recurrent training in their station on each shift and at weekly drills.

Volunteer fire fighter applicants must provide an application, including a statement of disability, a copy of their driving record, and references, and they must pass a police background check. Applicants' information is then reviewed by a board of directors before they are selected as members. Once selected as members, the volunteer fire fighters receive the same training as the career fire fighters. There is no State requirement for annual fire fighter recertification. Annual recertification is required for hazardous-materials certification. EMTs and Paramedics recertify every 3 years. The victim was trained as a Wildland Fire Fighter I, Driver/Operator, First Responder, and he had 9 years of fire-fighting experience.

Preemployment/Preplacement Evaluations. The Fire Department does not require a preemployment/preplacement medical evaluation for career or volunteer new hires. Preemployment/preplacement medical evaluations will be conducted beginning in 2002.

No timed performance evaluation of typical fire-fighting duties (physical ability test) is required.

Periodic Evaluations. No annual medical evaluations are required by the Department. Some fire fighters, however, possess a commercial drivers license (CDL) issued by the Department of Transportation. Applicants for a CDL are required

to have a medical evaluation performed by a physician.¹ The victim had not been evaluated for a CDL.

Medical clearance for SCBA, although not conducted by the FD, is required under State OSHA regulations.² This Fire Department will be conducting annual SCBA clearances beginning in 2002. If a fire fighter is injured on duty, he/she must be cleared for return to work by a physician approved by the State Worker's Compensation Board. In addition, if a fire fighter has a nonoccupational injury or medical condition resulting in one or more missed shifts, the Fire Chief can require that individual be cleared for return to work by his/her personal physician.

All fire fighters have access to a City-owned exercise facility that contains strength and aerobic equipment as well as tennis and basketball courts. Wellness programs, including annual health maintenance checks, are conducted by the City but are not mandatory for fire fighters or any other City employee.

DISCUSSION

The victim's autopsy was significant for several reasons. First, on visual examination, the right ventricle appeared dilated. Dilated cardiomyopathy is a condition characterized by dilatation of the heart chambers and impaired ventricular contraction (pumping). Microscopic findings are nonspecific, typically being myocyte hypertrophy with varying degrees of interstitial/perivascular fibrosis, or myofibrillar loss or myocyte atrophy.^{3,4} The victim had these nonspecific microscopic findings, but, for unclear reasons, not in his right ventricle. Although most cases of dilated cardiomyopathy are of unknown etiology (idiopathic), a variety of acquired or hereditary disorders can cause the disorder. These secondary and potentially reversible forms are listed in Table 2.⁴



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Given the victim's history, his most likely diagnosis was idiopathic dilated cardiomyopathy (IDC). Evidence against this diagnosis was that the dilation was noted only for the right ventricle, whereas the microscopic findings were localized to the sino-atrial (SA) node and his left ventricle and interventricular septum. In either case, the final conclusions/opinions expressed by the forensic pathologist conducting the autopsy were appropriate: "Probable cardiac dysrhythmia due to fibrosis of the conduction system of the heart." Although this victim had evidence of some atherosclerotic disease in one of his coronary arteries, it was highly unlikely to have resulted in a heart attack or to have triggered his arrhythmia.

IDC is not rare. Its age-adjusted prevalence in the United States averages 36 cases per 100,000 population,⁵ and it accounts for 10,000 deaths each year.⁶ Most patients are first seen between the ages of 20 and 50 years, presenting with symptoms of moderate heart failure (shortness of breath on exertion, palpitations [fast heart beats], diminished exercise capacity) and advanced heart failure (shortness of breath upon lying down and swelling of the ankles).⁴ This fire fighter had sudden death as the initial presentation of IDC. Although sudden death is rarely the initial presentation,^{7,8} it is a common cause of death among IDC patients, accounting for 28 percent of all IDC deaths.⁴

The prognosis for IDC is poor. Early studies reported 1- and 5-year death rates of approximately 25 and 50 percent respectively,^{9,10} but recent studies report an average 5-year death rate of 20 percent.^{7,8,11,12} This improved survival probably reflects the earlier detection of disease, a shift to population-based studies, and better treatment.^{8,13} Although a variety of symptoms and medical tests can provide prognostic information, patients at greatest risk of sudden death or in need of anti-arrhythmic therapy cannot yet be prospectively identified.⁴ Given the inability to identify patients at high risk for sudden

death, the low degree of efficacy of anti-arrhythmic agents for IDC, the numerous side effects of these anti-arrhythmic agents, and the lack of symptoms in this Fire Fighter, it is unclear if an earlier diagnosis could have been made, let alone prevented his sudden death.

Investigations into the pathogenesis of IDC have focused on four basic mechanisms: (1) inherited factors, (2) viral myocarditis and other cytotoxic insults, (3) immune abnormalities, and (4) metabolic, energetic, and contractile abnormalities. These mechanisms are not mutually exclusive, and several may combine to produce clinical disease in susceptible patients. The inherited factors account for approximately one third of all IDC cases,¹⁴⁻¹⁶ and 20 percent of patients with IDC have at least one first-degree relative with a decreased ejection fraction and cardiomegaly (enlarged heart).¹⁴ Although IDC can be transmitted as a recessive or X-linked trait, autosomal dominant inheritance occurs most frequently and exhibits both clinical variability and genetic heterogeneity.¹⁷ It is unclear if this victim's probable IDC was due to inherited factors or due to post-viral myocarditis. In either case, first-degree relatives of this Fire Fighter may want to consult with their physicians regarding whether an echocardiogram is warranted to screen for IDC.

In 2000, the National Fire Protection Association (NFPA) updated *Standard 1582, Medical Requirements for Fire Fighters and Information for Fire Department Physicians*.¹⁸ This voluntary industry standard specifies minimum medical requirements for candidates and current fire fighters. Dilated cardiomyopathy is not specifically addressed in the standard. However, at a minimum, it would be considered a Category B medical condition. A Category B medical condition is defined as "a medical condition that, based on its severity or degree, **could** (our emphasis) preclude a person from performing as a fire fighter in a training or emergency operational



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environment by presenting a significant risk to the safety and health of the person or others.” It is unclear whether the periodic medical evaluation recommended by NFPA 1582, including exercise stress testing (NFPA 1582, Appendix B),¹⁸ would have detected, let alone prevented, this unfortunate event from occurring.

RECOMMENDATIONS

The following recommendations address health and safety generally. It is unclear if 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 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: Conduct mandatory preemployment medical evaluations consistent with NFPA 1582 to determine a candidate’s 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, Standard on Medical Requirements for Fire Fighters and Information for Fire Department Physicians*¹⁸ and in the report of the International Association of Fire Fighters/International Association of Fire Chiefs (IAFF/IAFC) wellness/fitness initiative.¹⁹ The Department is not legally required to follow any of these standards. Nonetheless, we recommend the County and the Fire Department be consistent with the above guidelines.

In addition to providing guidance on the frequency and content of the medical evaluation, NFPA 1582 provides guidance on medical requirements for persons performing fire fighting tasks. NFPA 1582 should be applied in a **confidential, nondiscriminatory** manner. Appendix D of NFPA 1582 provides guidance for Fire Department Administrators regarding legal considerations in applying the standard.

Applying NFPA 1582 also involves economic issues. These economic concerns go beyond the costs of administering the medical program; they involve the personal and economic costs of dealing with the medical evaluation results. *NFPA 1500, Standard on Fire Department Occupational Safety and Health Program*, addresses these issues in Chapter 8-7.1 and 8-7.2.²⁰

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 #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.

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*¹⁸ and in the report of the International Association of Fire Fighters/International Association of Fire Chiefs (IAFF/IAFC) wellness/fitness initiative.¹⁹ The



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Department is not legally required to follow any of these standards. Nonetheless, we recommend the County establish the content and frequency to be consistent with the above guidelines.

Recommendation #3: 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, Standard on Medical Requirements for Fire Fighters and Information for Fire Department Physicians*. To ensure physicians are aware of these guidelines, we recommend that the Fire Department provide the contract and private physicians with a copy of NFPA 1582. In addition, we recommend the Fire Department not automatically accept the opinion of the employee's private physician regarding return to work. This decision requires knowledge not only of the employee's medical condition, but also of the employee's job duties. Frequently, private physicians are not familiar with an employee's job duties, or guidance documents, such as NFPA 1582. Lastly, we recommend that all return-to-work clearances be reviewed by the County/Fire Department contracted physician. Thus, the final decision regarding medical clearance for return to work lies with the County/Fire Department with input from many sources including the employee's private physician.

Recommendation #4: Follow provisions in the revised OSHA respiratory protection standard.

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. Washington is a State-plan State; therefore, public sector employers, including fire departments, are required to comply with OSHA standards. A copy of the OSHA medical checklist has been provided to the Fire Department.

Recommendation #5: Incorporate exercise stress tests into the Fire Department's medical evaluation program.

NFPA 1582 and the IAFF/IAFC wellness/fitness initiative both recommend at least biannual EST for fire fighters.^{18,19} 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 or the County's contract physician. If the fire fighter's personal physician conducts the test, the results must be communicated to the County physician, who should be responsible for decisions regarding medical clearance for fire-fighting duties.

Recommendation #6: Phase in a mandatory wellness/fitness program for fire fighters to reduce risk factors for cardiovascular disease and improve cardiovascular capacity.

NFPA 1500, Standard on Fire Department Occupational Safety and Health Program, and *NFPA 1583, Standard on Health-Related Fitness Programs for Fire Fighters*, require a wellness program that provides health promotion activities for preventing health problems and enhancing overall well-being.^{20,21} 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



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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.¹⁹ The Fire Department should review these materials to identify applicable elements.

Recommendation #7: Provide automated external defibrillators (AEDs) on fire apparatus.

Preservation of human life is the primary responsibility of the fire department during fires and other emergencies. Fire departments should be prepared to perform rescue work and provide emergency care for those injured.²² Such injuries include cardiac arrest. Most of the sudden cardiac deaths in the United States result from ventricular fibrillation. The chain of survival from cardiac arrest includes (1) early access to the emergency medical system (EMS and 9-1-1 system), (2) early CPR, (3) early defibrillation when indicated, and (4) early advanced emergency treatment.²³ AEDs have caused the cardiac arrest survivability rate to increase from 7 percent (CPR performed only) to 26 percent. When defibrillation is provided within 5-7 minutes, the survival rate is as high as 49 percent.²⁴ To provide emergency medical care, adequate supplies and equipment should be available to treat bleeding, fractures, cardiac arrest, etc. Placing AEDs on fire apparatus, in addition to those defibrillators carried on ambulances, would allow the Fire Department to provide a greater level of emergency medical care to the public.

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INVESTIGATOR INFORMATION

This investigation was conducted by and the report written by Tommy N. Baldwin, MS, Safety and Occupational Health Specialist. Mr. Baldwin is with the NIOSH Fire Fighter Fatality Investigation and Prevention Program, Cardiovascular Disease Component, located in Cincinnati, Ohio.



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Table 1. Response Timeline

Time	Response
1345 hours	Engine 512 (combination engine/tanker with 2,000 gallons of water) (one fire fighter and one officer [Incident Commander]) responded.
1346 hours	Additional assistance from Station 6 requested.
1347-1349 hours	The following units responded: Tender 518 (3,000-gallon tanker) (one fire fighter) Brush 596 (6-wheel-drive engine carrying 2,500 gallons of water) (one fire fighter) Grass 584 (1-ton pickup carrying 250 gallons of water) (one fire fighter) Engine 581 (combination engine/tanker with 2,000 gallons of water) (one fire fighter) Brush 585 (a 6-by-6 engine carrying 2,500 gallons of water) (one fire fighter)
1351 hours	Tender 598 (3,000-gallon tanker) (one fire fighter [the victim]) responded. Brush 585, Engine 512, and Brush 596 arrived on the scene.
1352 hours	Tender 518 arrived on the scene.
1353 hours	Tender 568 (3,000-gallon tanker) (two fire fighters) responded.
1356 hours	Grass 584, Engine 581, and Tender 598 arrived on the scene.
1358 hours	Tender 519 (8,000-gallon semi-tanker) (one fire fighter) responded.
1400 hours	Tender 568 arrived on the scene.
1409 hours	Tender 519 arrived on the scene.



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Table 2. Known Causes of Dilated Cardiomyopathy³

Toxins

Ethanol
Chemotherapeutic agents (doxorubicin, bleomycin)
Cobalt
Anti-retroviral agents (zidovudine, didanosine, zalcitabine)
Phenothiazines
Carbon monoxide
Lead
Cocaine
Mercury

Metabolic Abnormalities

Nutritional deficiencies (thiamine, selenium, carnitine)
Endocrinologic disorders (hypothyroidism, acromegaly, thyrotoxicosis,
Cushing's Disease, pheochromocytoma, diabetes mellitus)
Electrolyte disturbances (hypocalcemia, hypophosphatemia)

Infectious

Viral (coxsackie virus, cytomegalovirus, human immunodeficiency virus)
Rickettsial
Bacterial (diphtheria)
Mycobacterial
Fungal
Parasitic (toxoplasmosis, trichinosis, Chagas' disease)

Noninfectious

Collagen vascular disorders (scleroderma, lupus erythematosus, dermatomyositis)
Hypersensitivity myocarditis
Sarcoidosis
Peripartum dysfunction

Neuromuscular Causes

Duchenne's muscular dystrophy
Facioscapulohumeral muscular dystrophy
Erb's limb-girdle dystrophy
Myotonic dystrophy



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Photo 1.

Fatality Assessment and Control Evaluation
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Photo 2.