DEPARTMENT OF HEALTH AND HUMAN SERVICES

Public Health Service

National Institute for Occupational
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HETA 2011–0035

Ms. Michelle Ryerson
Chair, Risk Management Committee
National Wildfire Coordinating Group
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Dear Ms. Ryerson:

As per our conference call today, we are issuing this revised version of the closeout letter dated March 15, 2011, with the detailed information of each rhabdomyolysis case reviewed removed in order to provide an additional safeguard to protect case patients' identities when the letter is posted as per our regulation requirements.

On November 18, 2010, the Centers for Disease Control and Prevention (CDC) received a request from the National Wildfire Coordinating Group (NWCG) at the National Interagency Fire Center (NIFC) for epidemiologic assistance to determine the extent of rhabdomyolysis among wildland firefighters, and to identify possible risk factors unique to wildland firefighters. This type of request for urgent epidemiological assistance from the CDC is called an Epi-aid. Technical assistance to the Epi-Aid was requested from the National Institute for Occupational Safety and Health (NIOSH) on December 10, 2010 in the form of a Health Hazard Evaluation (HHE) request. These requests were prompted by the discovery of 10 rhabdomyolysis cases among wildland firefighters. An additional case was identified after the requests were submitted. CDC/NIOSH was also asked to provide preliminary recommendations for prevention of rhabdomyolysis prior to the start of annual spring training exercises. This letter summarizes our findings and provides recommendations for rhabdomyolysis prevention and early identification. Reducing delays in diagnosis and initiation of treatment is critical to preventing permanent disability and death.

Background

Rhabdomyolysis is the end result of any process that leads to the death of muscle tissue. When muscle tissue dies, electrolytes and large proteins that formed the muscle's contractile mechanism are released into the bloodstream [Khan 2009]. Potassium is the main electrolyte released into the blood by the death of muscle tissue. High levels of potassium can be lethal by causing irregular and dangerous heart rhythms and seizures. The large muscle proteins can damage the delicate filtration system of the kidneys. Classic symptoms of rhabdomyolysis are muscle pain, cramping, swelling, weakness, and decreased range-of-motion of joints. One of the signs of rhabdomyolysis is dark or tea-colored urine [Brudvig and Fitzgerald 2007; Khan 2009]. Symptoms can vary substantially between individuals. In some individuals, nonspecific symptoms such as fatigue, exercise intolerance, abdominal pain, back pain, nausea or vomiting, and confusion may predominate, while others might not have any symptoms at all [Huerta-Alardin et al. 2005; Brudvig and Fitzgerald 2007]. In one study only half of patients with confirmed rhabdomyolysis reported muscle pain or weakness [Cervellin et al. 2010]. Because muscle cramps and dark urine after prolonged exercise or a fire response may be the only sign and symptom a wildland firefighter may have, it is easy to see how rhabdomyolysis may be mistaken for heat-related illness and dehydration. This misdiagnosis has been documented in a previous study [Gardner and Kark 1994].

Rhabdomyolysis is diagnosed by measurement of creatine kinase (CK), also known as creatine phosphokinase (CPK), in the blood by a licensed health care provider.[*] The severity of rhabdomyolysis depends upon damage to other organ systems and the peak CK level.
Long term health consequences of rhabdomyolysis vary widely and largely depend on speed of recognition and treatment [Line and Rust 1995]. Mild rhabdomyolysis can be treated by drinking lots of fluids [George et al. 2010]. Severe cases require hospitalization and aggressive treatment with intravenous fluids to dilute the proteins to minimize their damage to the kidney, to monitor the heart for dangerous rhythm changes from the surge of electrolytes, and to monitor kidney function [Sauret and Marinides 2002]. In severe cases, the kidneys may fail and immediate dialysis is needed to mechanically remove proteins and electrolytes from the blood [Bosch et al. 2009]. The drop in kidney function may be temporary, but in some cases, kidney function does not recover, leaving a formerly healthy individual facing a lifetime of dialysis or possibly a kidney transplant. Up to 8% of cases of rhabdomyolysis are fatal [Cervellin et al. 2010].

Another potential serious complication of rhabdomyolysis is compartment syndrome which can occur if the damaged muscle is inside a fibrous sheath with other muscles, as is found in the arms and legs [Cervellin et al. 2010]. All muscles within the same sheath are considered to be in the same compartment. During rhabdomyolysis the injured muscle becomes inflamed and swollen. Because the fibrous sheath of the compartment cannot expand, the pressure from this swelling can become severe enough to prevent blood from entering the sheath, endangering all muscles inside that compartment. Unless the sheath is cut open by a surgeon to relieve the pressure and

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[*] Diagnosis requires a CK level greater than 1000 international units per liter of blood (IU/L) or five times the upper limit of normal concentration of that assay's reference range in combination with typical clinical symptoms or known risk factors [Cervellin et al. 2010]. A single CK below 1000 IU/L is not sufficient to exclude a diagnosis of rhabdomyolysis because CK levels begin to rise 2 to 12 hours, and peak 24 to 72 hours, after the initial injury [Khan 2009]. Repeat CK measurements must be done every 6 to 12 hours until a peak level is determined by documentation of two successive declining levels [Criddle 2003]. Urinary dipsticks that test for myoglobin in the absence of red blood cells are not a reliable screening method for rhabdomyolysis [Young et al. 2008].

restore blood flow, all the muscles in that compartment could die, resulting in permanent loss of function of the affected limb(s) [Walsh and Page 2006].

Risk factors for rhabdomyolysis include poor conditioning [Walsh and Page 2006]; heat stress/stroke [Huerta-Alardin et al. 2005]; dehydration [Line and Rust 1995]; prescription medications such as cholesterol-lowering statins [Chatzizisis et al. 2010] and antidepressants [Melli et al. 2005]; over-the-counter medications such as antihistamines [Melli et al. 2005], non-steroidal anti-inflammatory medications (e.g. ibuprofen, Advil®, Aleve®) [George et al. 2010], and omeprazole [Melli et al. 2005]; excessive caffeine intake [Wrenn and Oschner 1989]; use of dietary supplements such as creatine [Do et al. 2007] and Hydroxycut™ [Dehoney and Wellein 2009]; use of toxins such as alcohol or amphetamine [Huerta-Alardin et al. 2005]; underlying medical conditions such as sickle cell trait [Makaryus et al. 2007] or lupus [de Carvalho et al. 2010]; concurrent acute viral illnesses such as influenza [Nauss et al. 2009]; and overexertion [Line and Rust 1995].

Exertional (exercise-induced) rhabdomyolysis is the most frequently reported type of rhabdomyolysis in military trainees and athletes. The incidence of symptomatic exertional rhabdomyolysis in the general population is unknown [Alpers and Lones 2010]. Individuals in occupations that require prolonged, intense physical activity, such military personnel/recruits [Gardner and Kark 1994; Walsh and Page 2006], law enforcement [CDC 1990], and athletes [O'Connor et al. 2008] are at increased risk for developing rhabdomyolysis. Most cases of acute exertional rhabdomyolysis among military trainees occur during the first week of training [Olerud et al. 1974]. Repetitive exhaustive exercise regimens including "incentive training" using high-intensity repetitive exercises such as push-ups are more likely to lead to rhabdomyolysis than prolonged submaximal exercise regimens [Olerud et al. 1974]. While it is not uncommon for individuals in the general population who engage in exertional activities higher than their baseline level of fitness to develop exertional rhabdomyolysis, it also occurs in highly-conditioned individuals who may engage in supramaximal exercise or who have other risk factors concurrent with an exertional activity [Walsh and Page 2006].

Since 2006, nine wildland firefighters with laboratory confirmed rhabdomyolysis and two with suspected rhabdomyolysis (not confirmed by laboratory testing) have been identified by direct communication between employers and the NWCG. Six have been reported since April 2010. Two firefighters are permanently disabled from complications from rhabdomyolysis. While there has been little research specific to wildland firefighters, we can recognize risk factors that may place them at increased risk for rhabdomyolysis. These include training and work activities such as high intensity load-bearing exercise, frequent eccentric muscle contractions (movements where muscle is attempting to lengthen and contract at the same time), altitude, dehydration, and high levels of ambient heat or humidity [Line and Rust 1995; George et al. 2010]. Because there is no surveillance system for identifying rhabdomyolysis cases in any of the five constituent agencies of the NWCG, it is likely that the cases identified for review as part of this Epi-aid represent only a proportion of cases of rhabdomyolysis among wildland firefighters.

Methods

We visited the NIFC on January 11–13, 2011. An opening briefing was attended by approximately forty individuals, including NCWG staff, local fire chiefs, wildland firefighters, and others. We toured the Boise District Wildland Fire Headquarters, the Lucky Peak Helitack Base, and the Boise smokejumpers facilities. We interviewed staff at each location and obtained information about the training process unique to each type of wildland firefighter unit, including engine, fuels, modules, smokejumper, hotshot, Helitack, and hand. We conducted a focus group with six representatives from several of the NWCG's five constituent agencies to pre-test a questionnaire we developed for a possible follow-up study. We conducted on-site confidential medical interviews with two local firefighters identified as potential rhabdomyolysis cases and made initial contact by phone with the rest. A closing conference was held on January 13, 2011, to summarize initial findings and discuss potential future activities.

Since completion of the site visit, we have reviewed training materials and medical records, and interviewed most of the firefighters diagnosed with rhabdomyolysis and/or compartment syndrome.

Summary of Findings from Review of Cases

We were able to obtain medical records for seven cases. Information for three cases was obtained from telephone interviews only. One firefighter declined participation in this evaluation.

The 10 firefighters varied in age, type of wildland firefighter unit, assignment geography, symptoms, and outcomes. In half of the cases symptoms started on the first day of training, a new crew assignment, or the first day after completion of a fire response. The time between symptom onset and reporting of symptoms to supervisors varied from 30 minutes to 2 days. The time between symptom onset and arrival to a medical facility varied from 1 hour to 6 days. Five firefighters experienced disability for at least 3 months following discharge, and three of these have permanent disability.

Interviews of these firefighters revealed several important themes. Only one firefighter in this study knew of rhabdomyolysis prior to their diagnosis, and several attributed their symptoms to heat stress and/or dehydration. Most said they would have sought attention earlier if they knew about rhabdomyolysis and the potential for death or permanent disability. Several firefighters commented they did not report their symptoms to trainers or supervisors earlier because they felt it would harm their chances of completing a training program. The idea that one can and should "tough it out" when feeling tired or unwell so as not put an undue burden on other crew members by leaving to rest or seek medical attention was an important factor leading to delays in treatment for some of the firefighters in this study. Smokejumpers recruit trainees from other wildland firefighter crews. Once selected as a smokejumper trainee, an individual must quit their current job. However, employment as a smokejumper is dependent upon finishing the training program. Therefore, if a smokejumper trainee drops out of training to seek medical attention for any reason, including suspected rhabdomyolysis, they risk being unemployed.

Conclusions

All identified cases of rhabdomyolysis occurred during or close to either training or actual fire response activities involving high levels of physical exertion, often carrying heavy packs. Despite carrying the prescribed water supplies, dehydration played a significant role in over half of the cases and several firefighters reported inability or considerable difficulty accessing their water supplies during physical exertion. Lack of acclimatization, use of medications or dietary supplements such as creatine, as well as caffeine intake, and other health conditions such as upper respiratory tract infections and flu-like illnesses also were likely contributing factors for the cases of rhabdomyolysis we reviewed. Lack of knowledge about rhabdomyolysis led to delays in reporting of symptoms, as did inherent job disincentives to self-reporting. Triage by crew supervisors or EMTs that did not appear to account for the possibility of rhabdomyolysis as the cause of symptoms may have also led to delays in medical treatment. In a third of cases, there were delays in diagnosis or missed diagnosis of rhabdomyolysis by healthcare providers.

Recommendations

The following recommendations are provided to prevent rhabdomyolysis among wildland firefighters.

1. Create a formal training module on rhabdomyolysis and its risk factors, signs, symptoms, importance of early diagnosis, and consequences of delayed treatment. Integrate this module into annual training given to new and returning firefighters before the start of each fire season in June. Training should include the following:
    a. Explain rhabdomyolysis and its risk factors.
    b. Discuss signs and symptoms of rhabdomyolysis.
    c. Note that signs and symptoms can vary widely among individuals and can often mimic those of dehydration and heat related illness.
    d. Emphasize the need to seek immediate medical attention for symptoms that are atypical for the level of physical exertion, such as muscle cramps/pain or inability to do exercises/activities that had been done previously.
    e. Instruct those with signs and symptoms of rhabdomyolysis to remind their healthcare provider that they are at risk for this condition due to the nature of their work and to ask for a CK level.

2. Build flexibility into training programs for significant changes in weather. When ambient temperatures are much warmer than normal for the geographic area, supervisors should increase the frequency of scheduled hydration breaks, decrease weight of packs and gear carried, and use alternative water delivery methods to allow easier access to water, such as camel backpacks with a drinking tube attached to pack shoulder straps. If camel

backpacks are used, institute a protocol for tube and reservoir sanitizing to prevent illness from bacterial overgrowth due to inadequate cleaning of equipment.
3. Consult a physician with expertise in heat-related illness to give precise recommendations for acclimatization guidelines for incoming trainees, especially those coming from a geographical area with a cooler climate.
4. Consult a sports medicine physician to review training programs to maximize physical conditioning safely. This may include redesigning of training program schedules to allow for a gradual increase of physical exertion rather than having the period of maximal physical exertion fall on the first few days of training. Also, use longer duration, submaximal exercise routines instead of repetitive exhaustive exercises routines.
5. Contact each incoming firefighter and trainee about a week before they are to report for duty/training to ensure they are in good health and have completed off-season physical conditioning requirements.
6. Evaluate loads carried by firefighters during training and fire response. Although we recognize that bringing equipment to and from remote sites where wildfires often occur is challenging, consider increasing use of helicopter pick up stations to evacuate as much equipment as possible from the fireline. Heavy pack weight carried during these difficult hikes increases the risk for rhabdomyolysis. Since equipment is frequently delivered by parachute drops from aircraft, more effort should be spent on removing equipment by aircraft.

The following recommendations are provided to ensure firefighters receive early and appropriate treatment if they experience signs and symptoms consistent with rhabdomyolysis.

1. Minimize disincentives to reporting of symptoms.
2. Consider increasing the number of trainers/supervisors that accompany new firefighters during training exercises.
3. Develop a surveillance system to identify cases of rhabdomyolysis among wildland firefighters. This will serve as a critical foundation to further the study of specific risk factors for rhabdomyolysis among wildland firefighters. Ideally, this surveillance system should be standardized among the 5 agencies that NWCG oversees.

NIOSH is currently developing educational materials on rhabdomyolysis for wildland firefighters and healthcare providers along with a wallet-sized card for wildland firefighters. This card can be presented to a healthcare provider regarding firefighters' increased risk for rhabdomyolysis and the need to test for it if they present with signs and/or symptoms consistent with this condition. These materials will be sent to you and posted on the NIOSH wildland firefighting topic page at http://www.cdc.gov/niosh/topics/firefighting/ as soon as they are available.

Although one of the initial goals of this evaluation was to determine the extent of rhabdomyolysis occurring in wildland firefighters, this was not possible to address through a limited case series review. However, we plan on including this assessment as part of the protocol being developed for a follow-up HHE (HETA 2011-0079) to be conducted during an upcoming wildland firefighter training week. A more thorough assessment of incidence and prevalence of rhabdomyolysis among wildland firefighters will be possible once appropriate surveillance systems have been developed and implemented across the 5 component agencies of the NWCG.

This letter serves as a final report and concludes this health hazard evaluation. In accordance with the Code of Federal Regulations, Title 42, Part 85, Section 85.11, the employer must post a copy of this letter for 30 days at or near work areas of affected employees. Thank you for your cooperation with this evaluation. If you have any questions, please do not hesitate to contact us at 608-224-1192 (Dr. McFadden) or 513-841-4468 (Dr. Eisenberg).

Sincerely yours,

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Resources:

NIOSH Fire Fighter Fatality Investigation and Prevention Program:
http://www.cdc.gov/niosh/fire/

OSHA Quick Card — Protecting Workers from Heat Stress:
http://www.osha.gov/Publications/osha3154.pdf

USDA Forest Service, Wildland Firefighter Health & Safety Report: Issue No. 10:
http://www.fs.fed.us/t-d/pubs/htmlpubs/htm06512810/page03.htm

USDA Forest Service, Heat Illness Basics for Wildland Firefighters:
http://www.fs.fed.us/fire/safety/heat-illness.pdf

USDA Forest Service, Hydration Strategies for Firefighters:
http://www.fs.fed.us/eng/pubs/htmlpubs/htm08512324/

NIOSH Division of Safety Research, Fighting Wildfires
http://www.cdc.gov/niosh/topics/firefighting/

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