MILITARY MEDICINE, 167, 1:083, 2002

Case Report

Acute Management of White Phosphorus Burn

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White phosphorus is a combustible solid that is used in many of the smoke devices that are prevalent throughout the military arsenal. Exposure to phosphorus-containing compounds causes serious, often fatal, burns and can be the source of significant morbidity and lengthy hospital stays. I present the case of an individual with serious cutaneous phosphorus burns suffered at a munitions manufacturing plant. The purpose of this paper is to discuss the emergent treatments necessary in such patients and to discuss decontamination in the phosphorus-burned patient. Phosphorus-containing munitions are prevalent throughout the military arsenal, and all military physicians should be aware of these treatments.

Introduction

White phosphorus is a solid, waxy material that is used in many military munitions,[1] ranging from hand grenades to mortar, howitzer, and naval rounds. These weapons are prevalent throughout the military arsenal, and they are commonly used in military training exercises. Although often classified as incendiary, they are used predominantly to provide screening smoke. When detonated, they disperse numerous phosphorus particles that combust spontaneously on contact with air, bursting into a bright yellow flame and producing a thick white smoke.[2]

Although it is uncommon to encounter casualties from white phosphorus exposure, when this happens it can have dire consequences. When a person comes into contact with phosphorus agents, the phosphorus particles can become embedded in the skin, causing serious burns. These result from both the direct thermal damage of the burning particle and the corrosive action of phosphoric acid,[3] the by-product of burning phosphorus. Traditionally, serious burns have been fatal and, if not, have caused prolonged hospital stays and serious morbidity.

I present the case of an individual experiencing a large cutaneous burn from white phosphorous at a munitions manufacturing plant. In addition, the acute treatment and the controversy surrounding decontamination of such patients are discussed. As a result of the unique qualities of phosphorus burns and their management as well as the prevalence of white phosphorous devices in the military, all military physicians should be aware of the acute management of patients with phosphorous burns.

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This manuscript was received for review in September 2000. The revised manuscript was accepted for publication in July 2001.

Case Report

On January 2, 2000, a 50-year-old male worker at a phosphorus munitions manufacturing plant was attempting to clear a blockage in a tank containing solid white phosphorus when a valve burst, causing him to be covered with flaming phosphorus particles. He suffered extensive burns involving 36% of his total body surface area. His burns included full thickness injuries of the chest and axilla, with circumferential burns of his left upper extremity. He also suffered scattered partial thickness burns of his face, back, buttocks, and a thin rim surrounding the chest burn.

The patient was immediately stripped of his clothing and decontaminated using copious amounts of water by coworkers and responders to the scene. The patient was alert and oriented and breathing spontaneously, and all vital signs were in the normal range. Intravenous access was obtained in the right arm, fluid resuscitation was initiated, and oxygen was administered by face mask. A preliminary debridement was accomplished at the accident site by responding surgical personnel. This consisted of sharply removing sloughed skin that was still smoldering as well as removing all visible phosphorus particles with metal forceps.

After initial stabilization, the patient was transferred to a level II trauma center, where a second debridement was performed. The patient was then transferred to a regional burn center for definitive care. Upon arrival at the burn center, the patient had no evidence of carbonaceous deposits but had developed significant edema in association with the facial burn to the point that his left eye was swollen closed. He was also noted to have a cool and dusky left upper extremity, with a palpable radial pulse and pulses detected by Doppler signals in the digits. Soon after admission, digital Doppler signals were lost and an escharotomy of the extremity, carried over the wrist, was performed, with good return of perfusion to the extremity.

The patient was admitted to the intensive care unit, where he was treated with aggressive care, but no attempt at phosphorus decontamination was deemed necessary. Two skin grafts were placed, one to the left upper extremity 2 weeks after admission and the second to the left chest and axilla 4 weeks after admission.

The patient recovered well from both of the grafting procedures. He never demonstrated any cardiac disturbances, nor did he exhibit any evidence of systemic phosphorus poisoning during his prolonged hospital stay. After a 7-week hospital stay, he was discharged to a rehabilitation facility and was then discharged to home a short time later. His follow-up care to date has been uneventful.

Discussion

White phosphorus exposure causes serious burns that are characterized by slow healing and prolonged hospital stays,[2] as is demonstrated by this case. Phosphorus burns have been shown to cause death when only a small surface of the body is burned. A 12 to 15% body surface area burn in animals[4] has been shown to cause mortality. These numbers are similar to the mortality figures reported in humans, with phosphorus burns covering less than 10% of the body surface area reported to cause death.[5] This increased mortality has been theorized to be the result of systemic absorption of the phosphorus.[6]

Phosphorus continues to burn and to cause tissue destruction as long as it is exposed to oxygen or until all of the it has been consumed.[1] Therefore, it is of paramount importance to extinguish the phosphorus and to remove all contact with the phosphorus as quickly as possible. This should be done with water submersion if possible or by covering the wounds with saline- or water-soaked dressings.[2] All contaminated clothing should be removed. This should be followed closely by surgical debridement to remove embedded phosphorus particles. The particles may reignite if allowed to dry out,[7] hence the importance of keeping the skin moist. Tap water irrigation is the only treatment consistently documented to prevent death in phosphorus burns,[6,8] and it has been shown to decrease both the severity of the burn and the length of the hospital stay if copious lavage is performed in the field.[9]

Systemic phosphorus poisoning from phosphorus absorption from the burn site is a concern in any patient suffering from a serious white phosphorus burn. Although burns are very different from direct phosphorus ingestion, the burns can still lead to severe metabolic derangements and solid organ injury. Phosphorous burns have been demonstrated to cause hepatic necrosis.[4] The phosphorus also causes direct glomerular tubular damage, which has been shown to progress to acute renal failure in animals.[10] This renal failure has also been documented to cause potassium intoxication in association with cardiac arrest.[4] Patients have also developed decreased calcium that can progress to prolonged QT and ST intervals and T wave changes.[5] For these reasons, all patients, even those with smaller phosphorus burns who require admission, should be adequately volume resuscitated, transferred to a regional burn care facility, have electrolytes and liver functions monitored, and have continuous cardiac monitoring performed to assess for any cardiac rhythm disturbances.

Copper sulfate compounds were used formerly for decontamination of battlefield phosphorus burns. In addition to detoxifying the phosphorus,[11] these compounds cause retained phosphorus particles to turn black, making them easier to identify for removal.[12] Despite the fact that copper compounds neutralize phosphorus compounds in vitro, these compounds are actually harmful to patients. Topical copper compounds have been demonstrated to cause glucose-6-phosphate dehydrogenase competitive inhibition[13] and massive hemolysis, hemoglobinemia, and hemoglobinuria.[14] In addition, they have been attributed to cause death in white phosphorus burns as small as 7% total body surface area.[15] Copper emulsion formulas or copper suspensions have been advocated by some authors to be less toxic and more effective than the traditional preparations,[12,13] yet these emulsions are difficult to prepare and are stable for only a short time, and they have never been proven better than water irrigation alone.[6]

A safer and more practical alternative to the copper compounds is to use a Wood's lamp.[2] This causes the retained phosphorus particles to fluoresce, allowing easier surgical removal. This can be done easily at the bedside or in the emergency department without interfering with the management of the patient or delaying any necessary transportation.

Two important points are illustrated by this case. First, rapid decontamination with water and rapid surgical debridement obviate the need for decontamination with copper-containing compounds and can lead to good outcomes in patients with large white phosphorus burns. Second, this treatment coupled with expeditious treatment at a modern burn center can lead to good results in patients previously thought to have suffered a fatal burn.

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