

# From Smoke Inhalation to Chemical Attacks: Acute Cyanide Poisoning in the Prehospital Setting

Paul M. Maniscalco, MPA, DrBA(c), EMT/P

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George Washington University School  
of Medicine and Health Sciences,  
Washington, DC USA

**Correspondence:**

E-mail: paulm@gwu.edu

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**Abbreviations:**

CAK = Cyanide Antidote Kit

IPCS = International Programme on  
Chemical Safety

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The International Programme on Chemical Safety (IPCS)—a cooperative program of the World Health Organization (WHO), the International Labour Organization (ILO), and the United Nations Environment Programme (UNEP)—designates cyanide a priority chemical in relation to the potential impact on human health and the environment. Like other IPCS priority chemicals, cyanide is highly toxic, is a transboundary safety concern, is a target for risk management in multiple countries, is produced in large quantities, has dispersive use, and poses a risk for human exposure (Table 1).<sup>1</sup> Acute exposure to cyanide has caused significant morbidity and mortality in household and industrial accidents, as well as in suicides and attempted genocides, wars, and acts of terrorism. The most common, but perhaps least recognized source of cyanide in cases of acute poisoning is from smoke caused by fires.<sup>2</sup> This review is the product of a collaboration among experts in prehospital emergency medicine, public health and safety, and disaster preparedness. Current understanding of the causes, consequences, and management of cyanide poisoning are described as a potential advancement in antidotal therapy that could transform the provision of prehospital care to cyanide-poisoned victims.

Cyanide originates either from natural or human-made sources and can exist in gaseous, liquid, and solid forms.<sup>1,3</sup> It is among the most rapidly acting of poisons and, when present in sufficient concentrations, one of the most lethal. For example, exposure to moderate-to-high concentrations of hydrogen cyanide can result in death within seconds to minutes. Given the rapid progression of cyanide toxicity, prehospital responders arguably can impact the outcome of acute human exposure to cyanide more than any other category of healthcare provider. Prehospital responders usually are the first medical professionals to encounter and minister to the victim of cyanide poisoning. In many cases, whether the patient lives or dies depends largely on the prompt recognition of acute cyanide toxicity and/or interventions provided in the prehospital setting by the emergency responders.

Standard supportive care, including administration of 100% oxygen and cardiopulmonary resuscitation can help counteract cyanide toxicity, but successful intervention for moderate-to-severe poisoning entails administration of an antidote in addition to these supportive measures. The US prehospital responder's role in administering antidotal treatment has been limited somewhat by the lack of out-of-hospital options that have a good risk:benefit ratio. The Cyanide Antidote Package (also known as the Cyanide Antidote Kit (CAK), the Lilly Kit, the Pasadena Kit, and the Taylor Kit) is the only antidote currently available in the United States. The CAK can be associated with toxicities including hypotension, which can exacerbate shock, and methemoglobinemia, which reduces the oxygen-carrying capacity of the blood and can be particularly dangerous in oxygen-deprived victims of smoke-inhalation.<sup>4,5</sup>

The potential for antidote-induced toxicity becomes particularly problematic in the context of the need to administer it empirically in the prehospital setting. Cyanide poisoning must be diagnosed presumptively on the basis of limited information available at the scene, contextual clues, and symptoms and signs because results of blood tests are not available to confirm a diagnosis in time to initiate effective intervention. Treatment of presumed cyanide poisoning with the CAK potentially introduces risks that may outweigh the

- There is a probability of exposure
- Significant toxicity/ecotoxicity is possible
- The chemical:
  - Is of transboundary concern
  - Is of concern to a range of countries (developed, developing, and those with economies in transition) for risk management
  - Is traded internationally
  - Has high production volume
  - Has dispersive use

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**Table 1**—Properties of a typical chemical designated as a priority by the International Programme on Chemical Safety (IPCS)<sup>1</sup>

benefits in cases in which cyanide poisoning is diagnosed incorrectly. Therefore, the CAK rarely is used in the prehospital setting. In fact, many emergency medical services systems have opted not to carry the CAK on units, a choice that leaves the emergency-services provider with no antidotal treatment options for cyanide-poisoned patients.

Dr. Tee Guidotti of the School of Public Health and Health Services at George Washington University considers this barrier to effective prehospital care as well as other challenges in his paper, "Acute Cyanide Poisoning in Prehospital Care: New Challenges, New Tools for Intervention." Dr. Guidotti reviews the causes, recognition, and management of acute cyanide poisoning in the prehospital setting and describes the emerging profile of hydroxocobalamin—a unique antidote that appears to be suitable for empiric, out-of-hospital treatment. Hydroxocobalamin, which has been administered as an antidote for years in France, is being developed for potential introduction in the US. If made available in the US, hydroxocobalamin potentially could revolutionize the management of acute cyanide poisoning by facilitating rapid prehospital intervention.

The initiative to make hydroxocobalamin available in the US was fueled partly by the increasingly palpable threat of chemical terrorism involving cyanide. In his paper, "Terrorism Involving Cyanide: The Prospect of Improving Preparedness in the Prehospital Setting," Dr. Mark E. Keim, of the US Centers for Disease Control and Prevention, discusses the profile of cyanide as a chemical weapon and assesses the current state of preparedness in the US for a cyanide attack. He identifies several aspects of readiness that require improvement in order to manage a cyanide attack effectively and argues that stockpiling hydroxocobalamin is key to achieving adequate preparedness.

The potential availability of hydroxocobalamin in the US could improve the prehospital management of cyanide poisoning caused by inhalation of fire smoke. In the paper, "Focus on Smoke Inhalation—the Most Common Cause of Acute Cyanide Poisoning," Dr. Marc Eckstein of the Keck School of Medicine at the University of Southern California and the Los Angeles Fire Department, and this author review evidence suggesting that cyanide often is as important as carbon monoxide as a toxicant in fire smoke. This paper also discusses special challenges in managing smoke inhalation-associated cyanide poisoning. The inability to administer the CAK to smoke-inhalation victims safely constitutes one of the biggest challenges in providing help. Individuals exposed to smoke from fires almost always suffer from carbon monoxide poisoning in addition to toxicities caused by other substances such as cyanide. Carbon monoxide reduces blood oxygenation by displacing oxygen from hemoglobin. Components of the CAK also displace oxygen from hemoglobin and reduce blood oxygenation. In the carbon monoxide-poisoned victim who is administered the CAK, the additive oxygen-depriving effects of the antidote and carbon monoxide can be lethal. Dr. Eckstein suggests that, as hydroxocobalamin does not displace oxygen from hemoglobin or cause oxygen deprivation by any other mechanism and otherwise appears to be generally well-tolerated, it may become the treatment of choice for smoke-inhalation victims suspected of having cyanide poisoning. Data on the Paris Fire Brigade's successful use of hydroxocobalamin as an antidote for smoke inhalation-associated cyanide poisoning are discussed in the papers by Drs. Eckstein and Guidotti.

The possible availability of hydroxocobalamin in the US suggests the potential for improving outcomes for cyanide-poisoned victims. The prehospital responder will be crucial in realizing these improved outcomes. Emergency medical technicians and paramedics must recognize the public health threat posed by cyanide accidents or attacks and to be aware of the wide range of potential sources of cyanide poisoning—particularly the underappreciated but common one of smoke caused by fires. They must be familiar with the signs and symptoms of acute cyanide poisoning and be skilled in providing supportive and antidotal intervention. The prehospital responder can save lives by recognizing cyanide poisoning and promptly initiating corrective measures.

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