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CYANIDE POISONING AND CARDIAC DISORDERS: 161 CASES

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□ **Abstract—Background: Inhalation of hydrogen cyanide from smoke in structural fires is common, but cardiovascular function in these patients is poorly documented. Objective: The objective was to study the cardiac complications of cyanide poisoning in patients who received early administration of a cyanide antidote, hydroxocobalamin (Cyanokit®; Merck KGaA, Darmstadt, Germany [in the United States, marketed by Meridian Medical Technologies, Bristol, TN]). Methods: The medical records of 161 fire survivors with suspected or confirmed cyanide poisoning were reviewed in an open, multicenter, retrospective review of cases from the Emergency Medical Assistance Unit (Service d'Aide Médical d'Urgence) in France. Results: Cardiac arrest (61/161, 58 asystole, 3 ventricular fibrillation), cardiac rhythm disorders (57/161, 56 supraventricular tachycardia), repolarization disorders (12/161), and intracardiac conduction disorders (5/161) were observed. Of the total 161 patients studied, 26 displayed no cardiac disorder. All patients were given an initial dose of 5 g of hydroxocobalamin. Non-responders received a second dose of 5 g of hydroxocobalamin. Of the patients initially in cardiac arrest, 30 died at the scene, 24 died in hospital, and 5 survived without cardiovascular sequelae. Cardiac disorders improved with increasing doses of hydroxocobalamin, and higher doses of the antidote seem to be associated with a superior outcome in patients with initial cardiac arrest. Conclusions: Cardiac complications are common in cyanide poisoning in fire survivors. © 2010 Elsevier Inc.**

□ **Keywords—cyanide poisoning; fire smoke; ECG; cardiac disorders; hydroxocobalamin**

INTRODUCTION

Acute cyanide poisoning in humans is predominantly caused by smoke inhalation in fires and, much more rarely, by voluntary ingestion of cyanide salts. Little is known about the pathophysiology, clinical expression, and treatment perspectives. In addition to the classic respiratory and neurological clinical signs, there are also cardiovascular manifestations that are indicative of poisoning, the epidemiology of which is poorly documented. Although cardiac arrest and hypotension are rapidly identified, other signs should be recognized, such as rhythm, conduction, and repolarization disorders, especially in patients poisoned with low doses.

The aim of this study was to evaluate the frequency and type of electrocardiographic disorders in suspected or confirmed acute hydrogen cyanide poisoning patients, and also to assess the efficacy of early administration of hydroxocobalamin in correcting these disorders.

MATERIALS AND METHODS

An open, retrospective, multicenter (Paris, Besançon, Dôle, Montbéliard) study was conducted from January 1995 to July 2008 through a systematic review of 161 Emergency Medical Assistance Unit (Service d'Aide Médical d'Urgence; SAMU) medical records, and then from hospital admission records. As is common practice

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in France, the patients were first seen in the field by the SAMU, and were then admitted to various locations within the hospital, including the Emergency Department (ED) or Intensive Care Unit (ICU). The selection of the location did not depend on the patient's condition alone, but also on local habits or the availability of hospital beds.

Patients with smoke inhalation or cyanide salts ingestion were included in the study. All of them were treated with hydroxocobalamin as early as possible within the prehospital management. The analysis involved the electrocardiographic (ECG) tracings recorded on arrival of the medical team at the scene of the fire (n = 73) and continuous cardiac monitoring data (n = 88). These ECG tracings were recorded either before or at the beginning of antidotal administration. Blood cyanide levels were measured in 6 patients, 3 of whom were in cardiac arrest, whereas 2 had repolarization disorders, and 1 had supraventricular tachycardia. The dose of epinephrine and the application of external direct current shocks were recorded, as well as the main clinical signs (extensive burns, alterations of consciousness) and the determination of carboxyhemoglobin level. The patients' outcomes were assessed at the end of their hospitalization. This information was collected from the physician's clinical record, and by calling the doctor responsible for the patient after hospitalization. In the majority of cases, patients were hospitalized in a medical ICU or the ICU of a burn center, with a few patients being admitted directly to the ED.

The statistical analysis of the response to antidotal treatment was performed on the qualitative variables, represented by the size (n) and percentage (%) of the sample, and quantitative variables by their mean and 95% confidence interval. Qualitative variables (number of patients who survived, for example) were compared by a chi-squared test or by Fisher's exact test, depending on the sample size. Quantitative variables, like the dose of antidote, were compared using Student's and Kruskal-Wallis tests. Statistical analysis was performed using the Stata 9 program (StataCorp, College Station, TX).

RESULTS

Of the 161 patients with suspected acute hydrogen cyanide poisoning, 135 (84%) exhibited cardiac disorders confirmed on the initial ECG or monitor tracing (Table 1). Of the 61 patients found in cardiac arrest (Table 2), 58 exhibited an initial asystole, and 3 patients initially had ventricular fibrillation. Of the 31 patients (29 adults and 2 children) who spontaneously recovered cardiac activity (sinus rhythm) after administration of hydroxocobalamin, 5 patients survived without any sequelae (Figure 1).

Table 1. Groupings of Cardiac Disorders Observed

Cardiac Disorder	Number
Cardiocirculatory arrest	
Asystole	58
Ventricular fibrillation	3
Repolarization disorders	
Myocardial ischemia	5
Subendocardial lesion	7
Conduction disorders	
Intracardiac	5
Rhythm disorders	
Supraventricular tachycardia	56
Ventricular tachycardia	1
Total	135

In the 24 adult patients who died in the prehospital phase, the mean dose of hydroxocobalamin administered via a peripheral venous route was 4.37 ± 1.10 g (Table 3). In the 24 adult patients who had spontaneous recovery of cardiac activity after treatment, but who died in the hospital, the mean dose of antidote was 6.04 ± 2.07 g. Finally, in the 5 patients who survived and were discharged from the hospital without sequelae, the mean dosage used was 7.5 ± 2.5 g. One of these patients (No. 31) was 8 weeks pregnant (beta human chorionic gonadotropin = 1838 IU/L on hospitalization) and recovered without any sequelae, but with an intrauterine fetal death subsequent to the poisoning.

On univariate analysis, the differences in mean antidote doses between the three groups—cardiac arrest without recovery, cardiac arrest with early recovery but subsequent death, and cardiac arrest survivors—were statistically significant ($p = 0.01$). In the 5 patients who survived, cyanide levels in blood samples taken in the prehospital phase before administration of hydroxocobalamin showed a mean blood cyanide concentration of 4.76 ± 1.92 mg/L (2.5 mg/L are considered lethal), with values ranging from 3.4 to 6.12 mg/L.

Repolarization disorders were diagnosed after an ECG at the time of initial management in 12 patients (Table 4), 5 in the form of myocardial ischemia (T-wave inversion on the ECG), and 7 in the form of a subendocardial injury current (ST-segment elevation on the ECG). All of these patients received treatment with hydroxocobalamin at a dose of 5 g, as well as a follow-up ECG, performed either immediately after antidotal administration or on admission to the hospital after an interval of no more than 30 min. These traces showed the disappearance of the repolarization disorders after the administration of treatment (Figures 2, 3).

Intracardiac conduction disorders were recorded in 5 adult patients in the form of a left or right bundle branch block, with a mean QRS complex duration of 0.35 s (range 0.13–0.88 s, Table 5). These patients were not