J Forensic Sci, July 2004, Vol. 49, No. 4
Paper ID JFS2003278
Available online at: www.astm.org

TECHNICAL NOTE

James R. Gill,[1] *M.D.; Elizabeth Marker,*[2] *Ph.D.; and Marina Stajic,*[2] *Ph.D.*

Suicide by Cyanide: 17 Deaths

ABSTRACT: We reviewed 17 intentional ingestions of cyanide that occurred in New York City over a ten-year interval. The toxicologic and postmortem findings were reviewed. Certain occupations and nationalities of the decedents predominated among this group of suicides. Scientists, jewelers, and metal workers were common occupations among the decedents. In addition, 8 of 17 fatalities were West Indian/Caribbean Island and South American decedents, including three decedents from Guyana. Fourteen of the 17 fatalities were male. Pink lividity, a "bitter-almond" smell, and a hemorrhagic gastric mucosa were not prevailing findings in these decedents. A color test was used for screening for cyanide with confirmation and quantitation using gas chromatography.

KEYWORDS: forensic science, forensic pathology, cyanide, fatality, suicide

Although ingestion of cyanide is a quick and efficient method of suicide, it is rarely used in the United States (1–4). People who use cyanide to commit suicide often have ready access to the poison through their occupations. These occupations include chemists, jewelers, and others involved in pest control, mineral refining, photography, electroplating, dyeing, printing, and salmon poaching (3,5–8).

We reviewed all suicides by cyanide over a ten-year period in New York City that were investigated by the Office of Chief Medical Examiner (OCME). The autopsy and toxicologic findings, circumstances, nationalities, and occupations of the decedents were examined. This study confirms the occupational associations with cyanide poisoning and reveals various nationality associations of the decedents. In addition, certain commonly described autopsy findings in cyanide deaths are not supported. Due to the paucity of reliable autopsy findings in cyanide fatalities and the fact that not all toxicology laboratories routinely screen for cyanide, the pathologist must be aware of circumstances and risk factors that would suggest that cyanide testing should be performed.

Materials and Methods

The Office of Chief Medical Examiner investigates all unexpected, violent, and suspicious deaths in New York City. Toxicological testing was performed routinely on all autopsies and on select external examinations. All instances in which cyanide was identified by toxicological testing of postmortem samples from January 1990 to February 2002 were identified through the toxicology laboratory database with subsequent review of the OCME autopsy files and photographs. The OCME performed over 60,000 autopsies and toxicologic analyses during the study period. There are approximately 600–700 suicides per year in New York City.

Autopsy blood specimens were collected with the addition of sodium fluoride and stored at 4°C. All toxicologic testing was performed by the Forensic Toxicology Laboratory at the Office of Chief Medical Examiner. A color test (cyantesmo test paper) was used for screening for cyanide with confirmation and quantitation using gas chromatography. Cyantesmo test paper is used for the detection of hydrocyanic acid and cyanides in aqueous solutions (including blood and tissue homogenates). The pale green test paper turns blue in the presence of hydrocyanic acid. It has a sensitivity of 0.2 mg/L HCN after 15 min reaction time (Cyantesmo insert, Macherey-Nagel, Dueren, Germany).

Gas chromatography is used to confirm the presence of cyanide following a positive Cyantesmo test paper result. The limit of detection (LOD) is 0.125 mg/L and the limit of quantitation (LOQ) is 0.25 mg/L (9).

The conclusion that death was caused by an acute intoxication depends upon three conditions: the toxicology results are within the range typically encountered in such fatalities, the history and circumstances are consistent with a fatal intoxication, and the postmortem examination fails to disclose a disease or physical injury that has an extent or severity inconsistent with continued life.

Results

Cyanide was identified in samples from 143 deaths investigated by the Office of Chief Medical Examiner. After the exclusion of fire deaths, there were 17 deaths due to intentional ingestion of cyanide. There was one accidental death due to an inadvertent exposure to cyanide gas in a basement workshop. The circumstances, toxicology results, and causes of death are listed in Table 1. Fourteen decedents underwent autopsy with toxicologic analysis and three had an external examination with toxicologic testing. The ages of the decedents were between 25 and 85 years (average of 46 years) and 14 of the 17 were men. Eight decedents were from the West Indies/Caribbean

[1] New York City Office of Chief Medical Examiner and Department of Forensic Medicine, New York University School of Medicine, New York, NY.

[2] Forensic Toxicology Laboratory, New York City Office of Chief Medical Examiner and Department of Forensic Medicine, New York University School of Medicine, New York, NY.

Received 16 Aug. 2003; and in revised form 8 Nov. 2003, 6 March 2004; accepted 6 March 2004; published 26 May 2004.

TABLE 1—*Characteristics of cyanide decedents.*

	Age/Race/Sex	Occupation	Blood CN (mg/L)	Survival Interval	Location	Lividity	Birthplace
1	59 BF	unknown	160.0*	24 hours	home	red-purple	Jamaica
2	82 WF	housewife of a chemist	12.5	DOA	home	purple	USA
3	43 BF	medical analyst	152.6	DOA	home	purple	USA
4	29 HM	jeweler	12.8	DOA	work	purple	Santo Domingo
5	33 IM	medical student	61.5	DOA	home	purple	Trinidad
6	43 IM	accountant	41.9	DOA	home	purple	India
7	39 WM	computers	13.4	DOA	home	purple	Russia
8	57 WM	smelting, refinery	22.3	DOA	home	purple	USA
9	54 WM	scientist	123.3	DOA	lab	purple	USA
10	35 IM	jeweler	0.6†	DOA	beach	purple	Guyana
11	40 IM	mailman	22.8	DOA	home	purple	Guyana
12	38 IM	garment industry	17.3	DOA	home	dark red	Guyana
13	39 WM	computers	0.8	DOA (putrefied)	home	pink	England
14	25 WM	chemist	34.7	DOA	home	pink-purple	USA
15	85 WM	sheet metal	16.7	DOA	car	cherry pink	Germany
16	49 HM	jeweler	185.2	DOA	home	pink	Ecuador
17	28 BM	jeweler	11.4	DOA	home	not visible	Virgin Islands

* Hospital admission blood concentration.
† Received cyanide antidote kit in the hospital.

Islands or South America, including three from Guyana. Five of the decedents were born in the United States and one in India. There were no multi-fatality suicides or homicide-suicides.

The majority (14 of 17) had a known history of depression. A suicide note was found with 7 of 17 deaths and an additional four people verbally expressed a suicidal intent. The majority of ingestions occurred at home.

The blood cyanide concentration ranged from 0.6 to 185.2 mg/L. The average concentration was 37.6 mg/L. One decedent was putrefied and had a concentration of 0.8 mg/L. The amount of cyanide detected in the gastric contents in the nonhospitalized decedents ranged from 2.1 to 2217.6 mg (average 232 mg). Over half (9/17) had a documented hemorrhagic gastric mucosa at autopsy. Five decedents had a normal appearing gastric mucosa. The majority of decedents did not have pink lividity. A "strong odor" (not further detailed), was described for the gastric contents in one decedent. A "bitter almond" odor was not detected (5/17) or not reported in the remaining decedents.

Discussion

Three important findings are demonstrated by this study. These relate to the autopsy findings in cyanide deaths, potential risk factors associated with cyanide ingestions, and the toxicologic analyses in these deaths.

There are no reliable autopsy findings that are diagnostic of cyanide intoxication. The classic descriptions of the autopsy detection of cyanide ingestion include: pink lividity, an odor of "bitter almonds," gastritis, and oral/perioral erosions. The bright pink lividity has been differentiated from the "cherry pink" lividity of carbon monoxide poisoning. The pink or "lilac" lividity is not pathognomonic of cyanide poisoning and is not always seen in cyanide deaths. As other studies have also demonstrated, the pink lividity of cyanide poisoning is neither specific nor sensitive for cyanide intoxications (3,10,11). In fact, most of the decedents had purple lividity. Lividity may be pink for a variety of nonpathologic reasons, including refrigeration and putrefaction. One cannot rely upon the lividity to include or exclude cyanide intoxication as the cause of death. Cyanide testing should not be dictated by the color of the lividity.

The odor of "bitter almonds" is classically described in cyanide deaths. When it is detected, the scent is specific for cyanide intoxication. If one were to smell it, cyanide testing is indicated. The scent, however, is not always detected. With the recent proliferation of airflow respirators and high-flow autopsy rooms, people who are genetically able to detect the scent of cyanide may not detect it. Whether it is due to the genetic profile of the prosector (12), the method of cyanide administration (10), or sophisticated air protection systems, one may not detect the odor even if it is present.

Cyanide is a corrosive. It will gradually deteriorate tissue that it contacts. In an oral ingestion, the stomach may show signs of this corrosion by the mucosa appearing hemorrhagic. Corrosives do not need to illicit inflammation (as irritants do) to cause damage. Various microscopic epithelial morphological changes have been described in the gastroesophageal mucosa with cyanide ingestion (3). If the death occurs rapidly, one is unlikely to detect inflammation since it takes time to develop. Not every cyanide ingestion has a hemorrhagic gastric mucosa. This may be a reflection of the amount of cyanide ingested or the amount of food in the stomach at the time of the ingestion.

Since not all laboratories routinely test all decedents for cyanide, the paucity of autopsy findings may allow cyanide deaths to be missed. Therefore, it is important not to rely solely on the autopsy findings. One must always consider the circumstances. Recognition of certain factors should raise the pathologist's suspicion to a possible death by ingestion of cyanide. Certain occupations and nationalities should raise one's suspicion to test for cyanide. These occupations include those that have contact with cyanide. The use of cyanide to commit suicide by people who have easy access to it is predictable and expected.

Availability is one factor that determines the choice of a particular method of suicide. It is not surprising that a chemist can easily obtain cyanide. There are, however, other occupations with access to cyanide that are not as obvious. These include jewelers (13) and workers in industries such as pest control, photography, electroplating, dyeing, and printing. Jewelers use cyanide to rid gold of tarnish (personal communication, Tiffany and Company). Poachers poison salmon with a cyanide compound called Cymag. Miners use cyanide to separate various precious metals from ores. In certain cases, the occupation of the spouse of the decedent may be more important than the decedent's (see #2, Table 1). Since cyanide may

not be routinely tested for in all laboratories, it is important that the forensic pathologist inform the toxicologist of these suspicions along with an adequate history. Historically, the spleen has been a good sample to test because of its high content of red blood cells (14,15).

Guyana has had its share of tragedies with cyanide. The mass Jonestown suicide-homicides in 1978 involved the deaths of over 900 people (16). Gold mining operations in Guyana also have resulted in large-scale cyanide contamination of bodies of water. Cyanide is used to separate gold flakes from other materials in the second stage of the mining process. In August 1995, a cyanide-treated waste water poisoned a vast river system in central Guyana that was declared a natural environmental disaster zone by the Guyanese president. Knowledge of the lethality of cyanide due to local events and/or other cultural aspects may explain the nationality association of these deaths (17). It would be interesting to examine the methods of suicide in these geographic areas.

The postmortem interpretation of cyanide concentrations has pitfalls due to reports of both postmortem degradation and the production of cyanide (5,18–25). There was a broad range of blood concentrations in this study. There were two decedents (#10, #13, Table 1) who had much lower cyanide concentrations than the others. One of the decedents (#13) was putrefied, which may explain the low cyanide concentration, because cyanide deteriorates in the postmortem interval. A capsule that contained cyanide was detected in his stomach along with 6.2 mg of cyanide. The other decedent, however, was not putrefied. He was a 35-year-old jeweler and verbally expressed his desire to commit suicide. He was found unresponsive four hours later with potassium cyanide in a bottle by his side. He was essentially dead on arrival at the hospital; however, advanced resuscitation protocols, including a cyanide antidote kit, were attempted.

Cyanide antidote kits include sodium nitrite/sodium thiosulfate injections and amyl nitrite inhalational ampules. The nitrites cause production of methemoglobin. Cyanide will bind with greater affinity to methemoglobin than to cytochrome oxidase. The resulting compound may then be detoxified in the liver. Sodium thiosulfate promotes the conversion of cyanide to thiocyanate, which can be renally excreted. Administration of the cyanide antidote kit does not directly interfere with the toxicologic analysis, but it explains the low concentration since there is less cyanide available in the blood. Methemoglobin analysis was not performed.

References

1. Winek CL, Fusia E, Collom WD, Shanor SP. Cyanide poisoning as a mode of suicide. J Forensic Sci 1978;11(1):51–5.
2. Vogel SN, Sultan TR, Ten Eyck RP. Cyanide poisoning. Clin Toxicol 1981;18(3):367–83. [PubMed]
3. Fernando GC, Busuttil A. Cyanide ingestion. Case studies of four suicides. Am J Forensic Med Pathol 1991;12(3):241–6. [PubMed]
4. Cina SJ, Raso DS, Conradi SE. Suicidal cyanide ingestion as detailed in Final Exit. J Forensic Sci 1994;39(6):1568–70. [PubMed]
5. Chandra H, Gupta BN, Bhargava SK, Clerk SH, Mahendra PN. Chronic cyanide exposure—a biochemical and industrial hygiene study. J Anal Toxicol 1980;4(4):161–5. [PubMed]
6. Mutlu GM, Leikin JB, Oh K, Factor P. An unresponsive biochemistry professor in the bathtub. Chest 2002;122(3):1073–6. [PubMed]
7. Walrath J, Li FP, Hoar SK, Mead MW, Fraumeni JF, Jr. Causes of death among female chemists. Am J Public Health 1985;75(8):883–5. [PubMed]
8. Binder L, Fredrickson L. Poisonings in laboratory personnel and health care professionals. Am J Emerg Med 1991;9(1):11–5. [PubMed]
9. Zamecnik J, Tam J. Cyanide in blood by gas chromatography with NP detector and acetonitrile as internal standard. J Anal Toxicol 1987;11(1):47–8. [PubMed]
10. Ballantyne B. Autopsy findings following death by intramuscular hydrogen cyanide: an experimental study. Med Sci Law 1970;10(3):171–4. [PubMed]
11. Musshoff F, Schmidt P, Daldrup T, Madea B. Cyanide fatalities: case studies of four suicides and one homicide. Am J Forensic Med Pathol 2002;23(4):315–20. [PubMed]
12. Brown KS, Robinette RR. No simple pattern of inheritance in ability to smell solutions of cyanide. Nature 1967;215(99):406–8. [PubMed]
13. Adams VI, Hirsch CS. Trauma and disease. In: Spitz WU, editor. Spitz and Fisher's Medicolegal Investigation of Death. Springfield: Charles C Thomas,1993;185.
14. Adelson L. Pathology of homicide. Springfield: Charles C Thomas, 1974;854.
15. Sunshine I, Finkle B. The necessity for tissue studies in fatal cyanide poisonings. Int Arch Gewerbepathol Gewerbehyg 1964;20:558–61. [PubMed]
16. Brannon RB, Morlang WM. Jonestown tragedy revisited: the role of dentistry. J Forensic Sci 2002;47(1):3–7. [PubMed]
17. Elfawal MA. Cultural influence on the incidence and choice of method of suicide in Saudi Arabia. Am J Forensic Med Pathol 1999;20(2):163–8. [PubMed]
18. Lokan RJ, James RA, Dymock RB. Apparent postmortem production of high levels of cyanide in blood. J Forensic Sci Soc 1987;27(4):253–9. [PubMed]
19. Chikasue F, Yashiki M, Kojima T, Miyazaki T, Okamoto I, Ohtani M, et al. Cyanide distribution in five fatal cyanide poisonings and the effect of storage conditions on cyanide concentration in tissue. Forensic Sci Int 1988;38(3–4):173–83. [PubMed]
20. Padwell A. Cyanide poisoning. Case studies of one homicide and two suicides. Am J Forensic Med Pathol 1997;18(2):185–8. [PubMed]
21. Baud FJ, Borron SW, Bavoux E, Astier A, Hoffman JR. Relation between plasma lactate and blood cyanide concentrations in acute cyanide poisoning. BMJ 1996;312(7022):26–7. [PubMed]
22. Gill JR, Goldfeder LB, Stajic M. The happy land homicides: 87 deaths due to smoke inhalation. J Forensic Sci 2003;48(1):161–3. [PubMed]
23. Noguchi TT, Eng JJ, Klatt EC. Significance of cyanide in medicolegal investigations involving fires. Am J Forensic Med Pathol 1988;9(4):304–9. [PubMed]

Additional information and reprint requests:
James R. Gill, M.D.
Deputy Chief Medical Examiner
Bronx County
Office of Chief Medical Examiner
520 First Avenue
New York, NY 10016