CASE REPORT

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The Biohazard Potential of Cyanide Poisoning During Postmortem Examination

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ABSTRACT: A case of suicide by ingestion of cyanide salts provided an opportunity to determine whether personnel involved in postmortem examination of such cases are exposed to any significant degree of biohazard from cyanide remaining in body cavities or tissues of the decedent or both. It was found that potentially toxic concentrations of cyanide can develop in personnel so exposed. These findings have implications not only for the safety of pathologists and pathology assistants, but also for first responders (for example, police, firemen, emergency medical technicians [EMTs], paramedics, R.N.s) and emergency room personnel who may be involved in resuscitation efforts or removal of gastric contents or both in cyanide poisoning victims. Symptoms of cyanide toxicity and recommendations for reducing the potential for clinically significant cyanide exposure in medical settings are briefly reviewed.

KEYWORDS: pathology and biology, postmortem examinations, cyanide, biohazard

Cautions concerning the theoretical risk of the inhalation of toxic concentrations of fumes by personnel involved in the postmortem examination of cyanide poisoning victims are occasionally mentioned briefly in articles and standard texts [*1–3*]. Such admonitions typically refer to victims in which the poisoning was the result of ingestion of cyanide salts which, in reaction with gastric acid, could theoretically liberate hydrogen cyanide in sufficient amounts to pose a hazard to the pathologist(s) or assistant(s) examining or sampling gastric contents, or both. Exactly which precautions should be taken under such circumstances, however, are not further detailed in the literature.

This question is of some practical importance not only from a safety standpoint for pathologists and their assistants, but for first responders (for example, police, firemen, emergency medical technicians [EMTs], paramedics, R.N.s) and emergency room personnel. A recent case provided us with an opportunity to obtain data pertinent to these considerations.

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Case Report

A seventeen year-old chemistry student was found "unconscious" in his bedroom by his parents. The mother attempted mouth-to-mouth resuscitation, and the father called for assistance. Four law enforcement officers responded to the call, the first arriving within 3 min. The other three officers and paramedics responded shortly thereafter, and the decedent was pronounced dead at the scene. The scene investigation revealed a suicide note, a heating plate, and some chemicals near the body which were subsequently found to include potassium cyanide (0.073 kg), copper sulfate, and sulfuric acid.

After a caution regarding the possible inhalation of toxic fumes was given to those at the scene, one of the officers developed nausea and vomiting. He, together with the other three officers, both parents, and a ten-year-old sister of the decedent, were sent to a local hospital where they were examined for possible cyanide poisoning. The other three officers, the decedent's father, and sister were asymptomatic, and the only symptom elicited from the mother (who had attempted mouth-to-mouth resuscitation on the decedent) was some transient oral burning sensation. All were released shortly thereafter, except for the officer who experienced nausea and vomiting. He had developed an allergic reaction to a cyanide antidote he received before his cyanide blood concentration was obtained. His blood cyanide assay was subsequently found to be negative, and he was discharged the following morning.

The postmortem examination was performed sometime between 9 h and 20 min (when the decedent was last seen alive) and 4 h and 30 min (when the decedent was pronounced dead), after ingestion of the cyanide. The pertinent positive and negative findings included a strong odor of "burnt almond" readily detectable by only one of five persons who were present at some time during the examination, livor mortis which was slightly more red-pink than usual and had more marked red coloration of underlying musculature, moderate visceral congestion, and red/brown discolored gastric mucosa. The stomach contents consisted of 0.170 L of red/brown liquid with unidentifiable food fragments and were described as having an "extremely strong odor of bitter almonds." Microscopic examination revealed dark granular material on the mucosal surfaces of the esophagus and stomach, and slight pulmonary intraalveolar hemorrhage; other organs were microscopically unremarkable.

Toxicology examination of blood, bile, and gastric contents was carried out using routine broad-spectrum toxicology screening and the cyanide detection method of Reidens, a microdiffusion technique with subsequent chromophore development using chloramine-T and barbituric acid [*4*]. The blood samples from the decedent and the postmortem examination team were analyzed the same day they were drawn; bile and gastric contents were analyzed a few days later, using the same method. The decedent's results were positive only for cyanide, which was present in blood (1130 μmol/L; 29.5 μg/mL), gastric contents (0.0058 kg total), and bile (26 200 μmol/L; 683 μg/mL).

During the postmortem examination, which was performed in a room measuring 7.3 by 10.97 by 2.89 m, (24 by 36 by 9.5 ft), the following precautions were taken: A 1.2- by 0.45-m (4- by 1.5-ft) outside window, situated 1.82 m (6 ft) from the body, was opened and an exhaust fan (rated at 2683 m^3/s (4560 ft^3/min production) located on the other side of the body was turned on. Since the intake fan for this room produces 1883 m^3/s of air (3200 ft^3/min of air), the volume of air exchange would be somewhere between 1883 and 2683 m^3/s (3200 and 4560 ft^3/min), considering the open window provides an additional source of air intake. The three personnel who were present throughout the examination stepped outside for 3 to 4 min during mid-examination because of the perception of a very strong odor of burnt almond by one of them following removal of the stomach contents from the body by the autopsy assistant. The only subjective symptom occurring in these three personnel was a subtle lightheadedness experienced by the one individual who could perceive the cyanide odor. Blood samples taken within 10 min of the completion of the examination revealed whole blood cyanide concentrations of 38.4 μmol/L (1.0 μg/mL) in the medical examiner (a nonsmoker), 15.4 μmol/L (0.4 μg/mL) in the autopsy assistant (a cigarette smoker), and 11.5

μmol/L (0.3 μg/mL) in the resident pathologist (a nonsmoker) present. The relative amounts of cyanide in the examining personnel correlated well with their subjective impressions of duration of their close proximity to the decedent during the postmortem examination.

Comment

Blood cyanide concentrations in excess of 7.60 μmol/L (0.2 μg/mL) "suggest a toxic reaction," and serious poisoning is a risk with only modest elevated blood levels even several hours after exposure, according to Berlin [*5*]. The mechanism of toxicity involves a tight bond between the cyanide ion and the ferric ion of cytochrome oxidase, inactivating the latter and thus inhibiting electron transport, mitochondrial oxygen utilization, and cellular respiration [*6*]. Normal cyanide values are less than 7.60 μmol/L (0.20 μg/mL), and fatal cyanide poisoning has been reported with blood concentrations greater than 115 μmol/L (3 μg/mL) [*6*], or between 10 to 12 micromole percent [*7*]. Normal concentrations are generally much lower than the limit of 7.60 μmol/L (0.20 μg/mL) (a mean concentration of 0.610 μmol/L (0.016 mg/L) in nonsmokers and 1.57 μmol/L (0.041 mg/L) in smokers) [*8*].

It is estimated that about 50% of absorbed cyanide may be inactivated within 1h after exposure, being converted to thiocyanate by the liver enzyme rhodanase and excreted in the urine [*9*]. This suggests that the blood concentrations in the three personnel most exposed to the decedent during postmortem examinations were probably already declining at the time the blood samples were drawn.

Thus, our data show that it is possible for personnel involved in the postmortem examination of cases of poisoning by ingestion of cyanide salts to develop clinically significant cyanide concentrations by inhalation of cyanide gas from the body of the victim, even many hours after the victim's ingestion of cyanide and demise.

Our data do not answer the question of whether attempted mouth-to-mouth resuscitation of such patients would be hazardous. The decedent's mother was the only individual to attempt this in our case, her only subsequent clinical symptoms were limited to transient oral mucosa burning, and no blood sample for cyanide concentrations was drawn from her. In this regard, we note that Polson et al. [*3*, p. 179] cite the case of a wife who attempted mouth-to-mouth resuscitation on her cyanide-poisoned husband, and subsequently complained only of a "strange taste" in her mouth. Since blood cyanide concentrations were abnormally high in the medical examiner personnel, only one of whom experienced some slight neurological symptoms, the possibility of risk to individuals who performed mouth-to-mouth resuscitation in such cases cannot be excluded. We believe this should be brought to the attention of first-responders to such scenes, since mechanical ventilation devices are also commonly included in their available equipment and would seem a preferable respiratory resuscitative approach.

We would also recommend that samples to be tested for cyanide be processed as soon as possible. Cyanide concentrations in blood and tissues may either increase or decrease during storage in unpredictable fashion, and formalin-fixed tissue would be useless for subsequent analysis [*3,8,10,11*]. Sodium fluoride in a concentration of 1% w/v is reported to prevent the development of increasing cyanide levels with increasing storage time [*10*]. Usual laboratory precautions for potential toxins (gloves, face and eye protection, laminar-flow fume hoods, and so forth) are appropriate in this setting.

Susceptibility to development of symptoms of cyanide poisoning, as with other toxin exposures, is probably dependent on a variety of factors which include total dose, rate of absorptions, route of administration, host factors (age, health), and so forth. As described above, smokers typically exhibit blood cyanide levels higher than those present in nonsmokers. Whether such chronic exposure to cyanide enhances or diminishes the vulnerability of smokers to superimposed cyanide exposure is not known [*7*].

Personnel exposed to cyanide in laboratory settings should be familiar with symptoms and signs of cyanide poisoning commonly mentioned in the literature and summarized in Table 1 [*3,6,8,12,13*]. Upon development of such symptoms or signs, simple supportive measures (such as removal from the area and oxygen inhalation) rather than aggressive treatment with injectable antidotes would probably be appropriate in personnel with mild symptomatology because of the risks of significant side effects with some of the cyanide antidotes (for example, amyl nitrite, sodium nitrite, and aminopropiophenone) recommended in the literature [*6*]. Susceptibility to suggestion or other psychological factors in laboratory personnel and first-responders could also produce symptoms readily misinterpreted as an indication for administration of such antidotes (as may have been the case in one of the officers described in our case report) and is another factor to be weighed in treatment decisions.

It is clear that dependence on the appreciation of odor of cyanide (commonly described as "burnt almonds") as a warning symptom of excess exposure is quite unreliable. Between 20 and 40% of individuals cannot detect cyanide by odor, whereas others can allegedly detect as small a concentration as 38.4 μmol/L (1 ppm) [*2,8*]. Even the ability to detect the cyanide odor, which is presumably inherited as a sex-linked recessive trait [*14*], cannot necessarily be considered a very reassuring warning system for avoiding toxic concentrations. The only individual in our laboratory who could smell the cyanide was found to have the highest blood concentration, despite his leaving the room when he perceived bursts of increased cyanide odor as being strong enough to cause some concern for safety.

Our data regarding room size, window location, exhaust fan power, and so forth, are included in the case report to allow rough comparison with other autopsy suite designs. Technology is now available which provides for much more meaningful assessments of laboratory air-exchange efficiency such as calculation of the number of room air exchanges per hour, enthalpy (determination of the percent of fresh versus recirculated air entering the intake ducts to the room), and tracer dilution ventilation testing. The latter method is likely to provide the most direct answer to the question of how rapidly a toxic fume is reduced in a given room by the existing air conditioning system. This is also an expensive method (approximately $2500 in our region) and not readily usable.

Given the wide variety of laboratory settings in which such cases may be examined and the infrequency of this type of case, we believe a reasonable alternative safety precaution would be to limit exposure as much as possible as well as to perform blood cyanide determinations on personnel directly exposed to such cases immediately upon completion of the postmortem examination. Of course, if any exposed personnel were to develop symptoms suggestive of cyanide toxicity (Table 1) an immediate blood sampling for the concentration of cyanide would be appropriate and additional precautions taken at once to reduce further exposure.

TABLE 1—*Symptoms and signs of cyanide poisoning.*

"Dizziness," including true vertigo
Acid, burning taste; throat numbness; salivation; "frothing at the mouth"
Nausea, vomiting, substernal and epigastric burning pain
Anxiety, excess perspiration, giddiness, a sense of feeling "free" and able to pass through walls
Headache, confusion, drowsiness
Dyspnea; a sense of opression in the chest; cyanosis; hyperpnea, later bradypnea, hypopnea, and irregular respiration; characteristically a short inspiration and greatly prolonged expiration; pulmonary edema; respiratory arrest
Hypertension followed by hypotension; bradycardia followed by tachycardia, arrhythmias, and terminal asystole
Lactic acidosis
Loss of muscle power
Generalized tonic-clonic convulsions, trismus
Coma

By comparison of cyanide concentrations in the decedent with those in the examining personnel, it could be quickly determined at minimal cost whether a significant risk was present in one's own laboratory setting using standard protocols. If blood concentrations were insignificant, repeating such studies on personnel with every case of this type would not necessarily be indicated.

Finally, the pathologist, in his or her role as a clinical consultant, should be aware that successful cadaveric renal transplantation has been accomplished from a donor who suffered irreversible brain damage as a result of cyanide poisoning, indicating that the injury to nonneural organs in such cases can be reversible [*15*].

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