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Acute Benzene Poisoning: A Report of Three Fatalities

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ABSTRACT: The toxicity of benzene is well established, particularly its chronic effects on the hematopoietic system and its role as a carcinogen. Acute effects are known but less well documented. This case report describes three cases of acute benzene poisoning resulting from an industrial accident aboard a chemical cargo ship. Complete autopsies were performed on all three victims, who showed evidence of cutaneous, respiratory and cerebral injury. In addition, body fluids, brain, body fat, liver and lung were analyzed for benzene, levels of which were consistent with the lipid soluble nature of benzene, although body fat showed better correlation with blood levels than brain, liver or bile.

KEYWORDS: pathology and biology, acute benzene poisoning, body fluid and tissue analysis, industrial accident, accidental death

Benzene is an aromatic hydrocarbon that finds a multitude of uses in industry and household products, both as a solvent and as a building block for more complex aromatic compounds. Because of its widespread use, the dangers associated with chronic exposure were soon apparent, especially its adverse effects on the hematopoietic system. Its carcinogenic properties were also noted. Presently, its permissable exposure limit in the workplace is 1 ppm [*1*].

Whilst its chronic effects are well documented, reports of acute exposure are limited and are associated with industrial accidents and glue sniffing [*2–7*]. The following is a report of an industrial accident in which four victims were exposed to pure concentrated benzene fumes resulting in death in three of the victims within minutes of exposure.

Case Histories

While opening a flange valve in the cofferdam of a chemical cargo ship, four crew members were exposed to benzene fumes that had collected in the pipe from the previous cargo. Of the four, three died. None of the victims were wearing protective clothing. One victim (Case 2) saw the three crew members incapacitated by the benzene, donned a face mask with contained oxygen tank and attempted rescue. Having successfully

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FIG. 1—*Typical appearance of chemical burns in victims.*

rescued one crew member, he returned to attempt further rescue but was overcome by the benzene and died. Upon discovering the body, the oxygen mask was partially removed from the victim's face. The concentration of benzene to which the victims were exposed is unknown; the time frame of exposure was a matter of minutes. Complete autopsies were performed on all three victims. Samples of blood, body fat, brain, bile, liver, and lung were taken for benzene analysis employing headspace chromatography using a modification of the method reported by Sutheimer et al. [*8*]. Specimens of body fluids were collected in glass tubes, while body tissues were collected in plastic bags. All specimens were stored frozen until analysis was performed.

At autopsy, similar findings were present in all three victims, including second degree chemical burns to the face, trunk and limbs (Fig. 1), hemorrhagic airless lungs with confluent alveolar hemorrhage, and pulmonary edema (Table 1). The brains appeared grossly normal but showed microscopic evidence of prominent vascular congestion. Analysis of body fluids and tissue for benzene is shown in Table 2.

TABLE 1—*Autopsy findings in three victims.*

	Case 1	Case 2	Case 3
Age	25 yr	30 yr	39 yr
Percent burn	70%	20%	40%
Lung weight	1640 gm	1800 gm	1650 gm

TABLE 2—*Benzene concentrations in blood and various tissues.*

Tissue	Case 1	Case 2	Case 3
Blood	120 mg/L	30 mg/L	54 mg/L
Body fat	>120 mg/kg	68 mg/kg	88 mg/kg
Brain	58 mg/kg	62 mg/kg	63 mg/kg
Bile	trace	trace	45 mg/L
Liver	15 mg/kg	38 mg/kg	25 mg/kg
Lung	positive	positive	positive

Discussion

Benzene is a lipid soluble hydrocarbon which, in cases of acute exposure, result in cutaneous, respiratory, and cerebral injury. Benzene is rapidly absorbed through the respiratory system and also through the intact human skin [*9*]. The efficiency of absorption through the lungs is established and reported to be 46% of inhaled benzene [*10*]. While cutaneous absorption is recognized, accurate in vivo data regarding the rate of absorption is absent. In the above accident, the danger of cutaneous absorption is apparent. In case number two, the victim was wearing a self-contained breathing apparatus, which would presumably limit pulmonary exposure and subsequent absorption, yet they succumbed to the effects of the benzene fumes. It is tempting to speculate that a major route of absorption in this particular case would have been through the skin, although inhalation to one degree or another cannot be excluded; furthermore, the presence of pulmonary injury exhibited in this victim does not exclude significant cutaneous absorption or the possibility of indirect damage to the lungs. Whether the presence of second degree burns would have contributed to absorption via the skin is speculative but should be considered. In view of the potential for significant cutaneous absorption, the importance of wearing protective clothing becomes apparent, especially in workers whose occupation may entail the risk of chronic benzene exposure. The use of such protective clothing has been shown to reduce the likelihood of cutaneous absorption [*11*].

The mechanism by which benzene causes death in acute exposure is argued to be either through its anesthetic properties with resultant respiratory arrest and death [*5*], or through the production of a fatal arrhythmia in an adrenalin primed myocardium [*12*]. Clearly, in the present context, both mechanisms could be operational. In case number two, the history of death following attempted rescue in which the autonomic nervous system would be primed is a typical scenario of an arrhythmia-induced death.

The lipid soluble nature of benzene is well-known and is clearly demonstrated in the analysis of body fluids and tissues in the above cases. High levels of benzene are clearly present in both brain and body fat, although it is apparent that body fat better approximates blood levels than brain tissue. This may simply reflect, however, the nonhomogeneity of brain tissue in relation to the water content and the subsequent variation in measured water soluble and lipid soluble chemicals.

Liver, although useful to detect the presence of benzene postmortem, may not accurately reflect the blood level, while bile would appear of limited use. It must be remembered, however, that the number of cases is small and that further study is needed to confirm these findings.

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