DIETHYLENE GLYCOL POISONING: REPORT ON TWO CASES

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Few cases, if any, of death from drinking diethylene glycol have been reported in this country. This substance is, of course, largely used as an anti-freeze fluid in radiators of motor-cars, and is sold under a variety of trade names in this country, in America, and probably elsewhere, without any restrictions. There is little or no mention of the toxicity of this substance in British literature. It is not referred to in the latest editions of either Sidney Smith's (1943) or Glaister's (1945) textbooks, nor in Lucas's (1945) *Forensic Chemistry*. There is no mention of this substance in Hunter's (1943) monograph on "Industrial Toxicology." Bamford (1940) refers to the American "elixir" disaster referred to below. Brekke (1930) reported two fatal cases following the drinking of anti-freeze mixture.

An editorial article in the *Journal of the American Medical Association* (1937) describes and investigates a number of deaths in persons taking an "elixir of sulphanilamide." In all, seventy-three persons died as a result of taking this substance. The elixir was a mixture of 9-10 g. of sulphanilamide dissolved in 100 ml. of diethylene glycol. The dose recommended was three teaspoonfuls every four hours for one or two days. The most obvious symptom was anuria. Necropsy revealed a purplish mottling of the kidneys with necrosis in severe cases. It has been suggested by the American investigators of this disaster that sulphanilamide and diethylene glycol may produce additive toxic actions when given in combination.

Boemke (1943) reported an incident in which anti-freeze mixture was substituted for water in making coffee in a German military unit. Many men were dangerously ill and one died. It was suggested that death was due to uraemia caused by the oxidation of ethylene glycol to oxalic acid, which is deposited in the kidneys.

Pons and Custer (1946) describe details concerning ten soldiers who drank anti-freeze solution of ethylene glycol (Prestone type). Apparently this substance was drunk as a substitute for alcohol. They suggest that the minimum lethal dose is about 100 ml. The subjects were all young males. Death occurred in from twenty-two to forty-four hours after ingestion of the fluid. There was little opportunity to study clinical manifestations as all these cases were discovered in deep coma. Post-mortem findings showed generalized congestion of all organs and marked pulmonary oedema. The kidneys were swollen and displayed prominently engorged vessels. Crystals of calcium oxalate were prominent in microscopical preparations of the kidneys, mainly in the tubules. The brains were engorged and showed what the authors describe as "well developed encephalitis." They found numerous oxalate crystals in and about the engorged vessels of the brain. They suggest that coma and subsequent death were due largely to the cerebral complication. For this reason they also suggest that Brekke's two cases (1930) survived, not—as the author suggests—because there was unilateral decapsulation of the kidney, but rather because the amount of ethylene glycol they took was sublethal.

Milles (1946) reported a case of a man aged 30 who drank from a car radiator about 500 ml. of fluid that had had anti-freeze mixture added. The man died ten hours later with symptoms of heart failure and oedema of the lungs. At necropsy the kidney tubules were found to be swollen and disorganized. There were abundant deposits of calcium oxalate crystals in the tubules. He suggests, also, that the cause of death in ethylene glycol poisoning is essentially poisoning from oxalic acid, and cases should be treated as if that substance were the causal agent.

Accounts of the toxicology of the glycols are conflicting and not very precise. Page (1927) says he drank 15 ml. of ethylene glycol without ill effect.

Keston and others (1937) studied the toxic doses of diethylene glycol on rats and rabbits. A dose of from 1 to 2 ml. per kg. of diethylene glycol in rats was required to produce pathological changes, which consisted of extensive injury to the epithelium of the renal tubules, leading to urinary obstruction and uraemia. Holck (1937), in experiments on rats, found that 20 per cent of commercial diethylene glycol in their water killed all rats in about two weeks, and even 10 and 15 per cent proved fatal to some rats. Laug and others (1939) stated that ethylene glycol caused congestion and haemorrhage of the lungs. Smyth and others (1941) used rats and guinea-pigs. The animals were given the very large dose of 50 g. per kilo of various glycols by stomach tube. Most animals died within two days. The lethal dose of diethylene glycol appeared to be about 20 g. per kilo for rats.

Morris and others (1942) fed rats with ethylene and diethylene glycol at levels of between 2 and 3 per cent. The outstanding lesions were large stones in the bladder, tubular atrophy, and renal oxalate concretions. Most of the animals survived a two-year period of feeding. Sollmann (1942) described ethylene glycol as being twice as toxic as propylene glycol and half as toxic as diethylene glycol. Werner and others (1943) subjected rats to repeated exposures of vapours of ethylene glycol and related substances. The concentrations used were not enough to produce any obvious degeneration of the kidneys. Lehmann and Flury (1943) state that the effects of glycol poisoning are due to the formation of oxalic acid in the kidneys.

Case Reports

Case 1.—The fatal case now described was a young man aged 25, a German prisoner-of-war. He appeared back in camp with a bottle of fluid, saying that it had been given him as a present by a civilian. At the inquest later no light was thrown on how the man obtained this fluid. One evening he drank a good deal, perhaps the best part of half a winebottle, and offered some to others; in fact two other prisoners had a little.

He was admitted to the City Hospital, Plymouth, and died about twenty-four hours after drinking the fluid. It was found later that the fluid in the bottle was pure diethylene glycol. On admission he was in a deep coma and deeply cyanosed.

Necropsy.—The body was that of a well-nourished very muscular young man. The face was deeply cyanosed and blood-stained, with froth oozing from the mouth and nose. The heart muscle was softer than to be expected in a healthy young man. The lungs were intensely congested and oedematous. The mucous membrane of trachea and bronchi were bright red in colour and full of blood-stained mucus. The liver was pale and fatty in appearance. The stomach and intestines showed no lesions. The kidneys were deep red and of a greasy appearance, and showed great engorgement of cortical vessels. The brain was very congested but showed no other abnormalities to the naked eye. The bladder was distended. The urine contained a cloud of albumin, and a few leucocytes and red cells were present.

Microscopically all the liver cells showed cloudy swelling, and there was a slight amount of fatty degeneration. The kidneys showed intense tubular degeneration and swelling; hardly any nuclei were visible. In the lumen of numerous tubules crystals were prominent.

At first sight the appearances were those that would be expected in a case of poisoning by methyl alcohol, but by the time the necropsy was performed it was known that he had in fact drunk diethylene glycol, and particular attention was paid to the residual urine in the bladder and to the condition of the kidneys. At this time there had been no opportunity of surveying the literature, and it is regretted that a detailed microscopical examination was not made of the brain in view of Pons and Custer's observations referred to above.

Case 2.—The second man who also drank some of the fluid, perhaps 2 or 3 mouthfuls, was a healthy young man of 28; he had been slightly sick during the night following. He also was admitted to the City Hospital, Plymouth. On admission his colour was good but the tongue was furred; he had slight headache and some vomiting shortly after admission. He passed 27 oz. of urine during the night. The next day he felt better and was allowed up. On the sixth day after admission, however, he had repeated fits, his blood urea was found to be 390 mg. per 100 ml., and there was almost complete anuria; now that the cause of death, the nature of the fluid drunk, and the post-mortem findings of the first case were known, it was decided to perform decapsulation of the kidneys. This was done by the Medical Superintendent of the City Hospital, Mr. G. Larks.

Operation.—At operation the capsule was stripped from each kidney. There was considerable peri-renal oedema. Each organ was enlarged, congested, and bluer than normal. The tension inside the capsule was such that on incision of the capsule the kidney bulged quite markedly, the capsule stripped without

assistance, and the surface of the kidney became immediately redder.

The anaesthetic employed was a "high spinal," using novocain with pentothal, nitrous oxide, and oxygen.

Progress.—The man steadily improved and made an uneventful and perfect recovery. The blood urea findings were:

Just before operation, 390 mg. per 100 ml.
 2 days after operation, 310 mg. per 100 ml.
 3 days after operation, 210 mg. per 100 ml.
 5 days after operation, 105 mg. per 100 ml.
 10 days after operation, 30 mg. per 100 ml.

Case 3.—The third case was also a healthy young man, who is said to have had just a taste of the fluid. On admission to the City Hospital his condition was described as good, and he was in fact admitted only as a precaution. He had a little vomiting and headache during the night following the drinking of the fluid. There was a considerable amount of albumin in the urine, but no cells or casts. His blood urea on admission was 90 mg. per 100 ml. He made an uninterrupted recovery.

Comment

Without doubt diethylene glycol is a very toxic substance; if any general tendency develops to drink it as a substitute for alcohol, the results may be disastrous. The range of the lethal dose in man seems to be quite unknown.

Methods of treatment require investigation, and it has still to be decided whether or not treatment should be that for oxalic acid poisoning; it seems certain that the kidneys bear the brunt of the damage.

It would seem from the second case quoted in this paper that in very severe cases decapsulation of the kidneys may be a life-saving measure.

In view of Pons and Custer's findings, further observations on the histology of the brain should be undertaken.

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