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EFFECT OF ALCOHOL INTOXICATION ON TOXICOKINETIC INDICES IN ACUTE ACETIC ACID POISONING

Sultanova N. D. [1]***, Iskandarov A. I.*** [2]***, Yadgarova Sh. Sh*** [2]

[1] Tashkent city branch of the Republican scientific and practical center of forensic medical examination. Tashkent, Republic of Uzbekistan

[2] Department of Forensic medicine of the Tashkent Pediatric Medical Institute; Tashkent, Republic of Uzbekistan

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Abstract

The article presents data from a retrospective analysis of 40 victims and 30 corpses, persons who died from acute acetic acid poisoning against the background of alcohol intoxication. The toxicokinetics were assessed according to the WHO guidelines (1981). The nonlinear resistance analysis method was used to determine the main parameters of toxicokinetics: the elimination rate constant, the half-life of the poison in the blood, and the maximum duration of the toxicogenic phase in acetic acid poisoning against the background of alcohol intoxication.

Keywords: *toxicokinetics, elimination rate constant, half-life of poisons in the blood, maximum duration of the toxicogenic phase*

Relevance of the problem:

Forensic examination of acute poisoning is one of the important and complex sections of forensic toxicology. Statistics show that a significant number of the total number of acute poisonings are caused by cauterizing poisons, including acetic acid (Kazsuba A., Viter A. et all., 2000; Penner G. E. 2008; Zamir O., Hod G. et al., 1985). Acetic acid is widely used in everyday life. Among the causes of poisoning with this poison, suicidal tendencies (Akhmedov D. A., 2019; Akhunov A. A., 1989; Klimov I. A., Gorbakov V. V., 2009) and accidental poisoning prevail, although accidental poisonings are fatal.

Acute oral poisoning with acetic acid is characterized by a severe course and high mortality (WHO Guidelines, 1981; Mills S. W., Okoe M. I., 2007; Weintraub B. A., 2007).

The clinical and morphological picture of acute poisoning with acetic acid has been studied for a long time. However, the main studies concern the pathogenesis, clinical picture and treatment of these intoxications. Thus, Rusakov A. V. (1930) was the first to establish an expert opinion on hemoglobinuric nephrosis in cases of poisoning with acetic essence, as the most characteristic complication of intravascular hemolysis, and N. K. Permyakov in 1979 proposed an

original classification of the stages of developmenthemoglobinuric nephrosis and by the nature of the disorders in the kidneys, substantiating the possibility of determining the duration of hemolysis. However, these studies were purely empirical in nature, and the effects of free hemoglobin in acid poisoning on the entire area of morphological changes in the internal organs have never been systematically studied. It is known that in everyday life, acetic acid poisoning is accompanied by alcohol intoxication (10). How concomitant alcohol intoxication leads to the removal of poison from the body and in the available literature was not found.

Purpose of the study:

To study the toxicometry of acute poisoning with acetic acid for toxicokinetics of the poison and to develop exogenous criteria for quantitative assessment.

Materials and methods:

This study is based on 140 cases of acute non-ideal poisoning with acetic acid, of which 92 cases (65.7%) were poisoned against the background of alcohol intoxication. Of these, 75 cases (81.5%) were poisoned with suicidal intent and only 17 cases were due to accidental ingestion of poison. The victims were treated at the Republican Scientific Center for Emergency Medical Care in the toxicology department. Forensic medical examination of corpses was carried out according to the generally accepted method in the first 10––8 hours, but not later than 24 hours after death.

In all expert cases, poisoning with acetic acid against the background of alcohol intoxication was confirmed by the case materials, the clinical picture of the poisoning, the results of the forensic medical examination of the corpse and the data of the forensic chemical and toxicological examination.

The severity of acute acetic acid poisoning was assessed based on the extent of chemical burns of the gastrointestinal tract, the shift in capillary blood pH, and the level of intravascular hemolysis.

In the clinic, when assessing the severity of the pathological process, they mainly focused on the level of hemoglobinemia, i.e. the concentration of free hemoglobin in the blood.

Ethyl alcohol was determined in a forensic chemical laboratory using liquid chromatography methods.

We assessed the toxicokinetics of the poison according to the WHO guidelines (1981). The kinetics of diffusion processes is described by exponential laws and is called first-order kinetics. In this case, the rate of change in the concentration of the poison in the blood plasma can be expressed as a linear differential equation:

$$\frac{d}{c} = Ke \times C(t)dt$$

Where: *C(t)* is the concentration of poison in the blood plasma at time *t*; Ke is the elimination rate constant.

Solutions of this differential equation with initial conditions *C(t) = C(o)* at the time of admission of the victim to the hospital (zero time) gives:

$$C(t) = C(0)^{-Kext}$$

Based on this model, the following main parameters of acetic acid toxicokinetics were determined using the nonlinear resistance analysis method: the rate constant of elimination of the poison, the half-life of the poison in the blood, and the maximum duration of the toxicogenic phase of poisoning.

The elimination rate constant (*Ke*) shows what proportion of the total amount of toxic substance present in the circulatory system is removed during each time interval; it is measured in units of inverse time (*l/t*).

The half-life of a poison in the blood is the time required for its concentration to decrease by half. This indicator, widely used in theoretical toxicology, is designated as T ½ and can be determined from the equation:

$$T_{1/2} = \frac{\ln 2}{Ke} = \frac{0.693}{Ke}$$

The maximum duration of the toxicogenic phase is determined by the time the poison is present in the blood.

Results and discussions

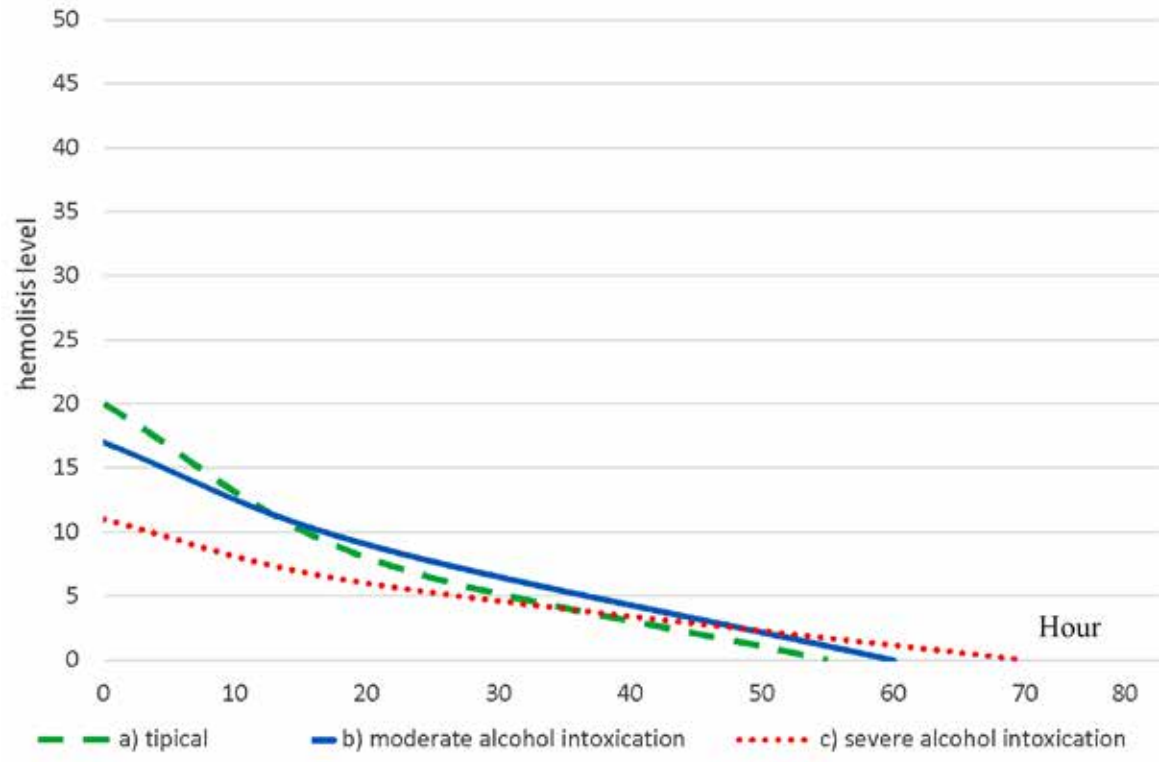
Based on the kinetic model presented in the “Materials and Methods”, using a computer and the method of nonlinear repressive analysis, the above parameters of the toxicokinetics of acetic acid (Table No. 1) and

their changes against the background of alcohol intoxication of varying degrees were quantitatively determined.

Table 1. *Toxicokinetics of acetic acid against the background of alcohol intoxication*

Acetic acid and concomitant alcohol intake of varying degrees	Initial blood poison level (free hemoglobin mg/ml)	Ke	T ½ (hour)	Maximum duration of the toxicogenic phase (hours)
Acetic acid (free hemoglobin)	12.3±4.73	0.043	16.5	56
Free hemoglobin in combined moderate alcohol poisoning	11.8±5.12	0.039	17.8	59
Free hemoglobin in combined severe alcohol poisoning	10.40±3.72	0.027	23.6	64

Figure 1. *Toxicokinetics of free hemoglobin in acetic acid poisoning against the background of alcohol intoxication: a) typical; b) moderate alcohol intoxication; c) severe alcohol intoxication*



As follows from the table, if the rate of elimination of acetic acid from the blood can be estimated as comparatively high in acute poisoning with acetic acid alone (0.043), and in combined poisoning with this poison against the background of moderate alcohol intoxication (1.5–2.5‰), as moderate with Ke-0.039, T ½ –17.8 hours with the duration of the toxicogenic phase – 59 hours, then in combined poisoning with acetic acid and severe alcohol intoxication (2.5–3.5‰ and more). Ke was equal to 0.027, i.e. the rate of elimination of the poison from the body was much lower than in isolated poisoning with acetic acid alone. Moreover, even with an initial value of the free hemoglobin level equal to 10.40±3.72 mg/ml, much lower than in isolated poisonings (12.3±4.78), the half-life of the poison (free

hemoglobin) was 23.6 hours (versus 16.5 hours in isolated poisoning), and the maximum duration of the toxicogenic phase increased from 56 hours to 64 hours (P<0.01).

Thus, it can be stated that in acute poisoning with acetic acid against the background of alcohol intoxication, the main indicators of the toxicokinetics of acetic acid change significantly and depend on the degree of intoxication of the victims, which must be taken into account in the expert assessment of the severity of chemical injury. Figure 1 shows the standard kinetic curve (graph) based on the toxicokinetics of free hemoglobin against the background of alcohol intoxication of varying degrees.

According to modern views, the pathogenesis of acute poisoning should be studied in two aspects: what the poison does to the body and what the body does to the poison. To solve this problem, the method of covariance analysis was used. As part of our studies, we determined the effect of exotoxic shock on the kinetics of free hemoglobin, since exotoxic shock is one of the main causes of death in acid poisoning (Table 2).

Table 2. *The effect of decompensated exotoxic shock on the kinetics of free hemoglobin in acetic acid poisoning against the background of alcohol intoxication*

Types of acetic acid poisoning	Baseline free hemoglobin level (mg/ml)	Ke	T ½	Maximum duration of the toxicogenic phase
Acetic acid:				
1) hemodynamics are stable	11.62±8.76	0.036	22.6	58
2) Decompensated shock	22.34±9.36	0.028	28.2	64
Acetic acid against the background of alcohol intoxication:				
1) hemodynamics are stable	16.50±48.28	0.026	29.6	68
2) Decompensated shock	24.18±9.36	0.034	24.6	60

Changes in the main parameters of toxicokinetics of free hemoglobin against the background of exotoxic shock are primarily associated with the disruption of the pathways for removing the poison from the body. According to our observations, exotoxic shock is naturally accompanied by oliguria and a significant delay in the fluids removed from the body. Since the removal of free hemoglobin from the body is carried out mainly through the urinary system, it is natural that under these conditions the toxicokinetics of the poison is also disrupted.

As follows from the data of Table 2, acetic acid poisoning against the background of alcohol intoxication proceeds in exotoxic shock in a completely ambiguous manner. Here, alcohol in small concentrations (from 1.5 to 2.5‰) has a favorable effect on the course of poisoning. Thus, with an initial hemolysis level of 24.18 ± 9.36 mg / ml, the elimination rate constant has a value of 0.034, i.e., an acceleration of the rate of elimination of free hemoglobin from the bloodstream is observed, and the half-life of the poison in the blood is equal to 24.6 hours, the maximum duration of the toxicogenic phase is shortened to 60 hours. This effect of alcohol in small concentrations is apparently due to the fact that alcohol activates metabolic processes in the liver, which ultimately leads to the rapid elimination of the poison from the bloodstream, which leads to a more accelerated exit of the body from the state of decompensated shock. However, it should be noted that such a beneficial effect of alcohol on the course of decompensated shock is observed only with moderate alcohol intake. With ethyl alcohol concentrations in the blood of more than 2.5–3.0‰, we noted a sharp deterioration in the condition of the victims and often exotoxic shock led to a fatal outcome.

Thus, the results of these studies showed the forensic significance of the degree of hemolysis and the main patterns of its tox-

icokinetics and their changes against the background of alcohol intoxication.

Conclusions:

1. The outcome of chemical trauma largely depends on how quickly and effectively the absorbed dose of poison can be eliminated.

2. The use of graphs for assessing the main parameters of free hemoglobin kinetics in cases of acetic acid poisoning allows for a quantitative assessment of the risk of death and the effectiveness of detoxification measures.

3. The effect of concomitant alcohol intoxication in acetic acid poisoning on toxicokinetic indices is not clear and depends on the initial concentration of ethyl alcohol in the blood.

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Contact: sudmeduztash@gmail.com; iskandarov50@mail.ru; shabnamibragim@gmail.com