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Toxicological Data for Fatalities due to Carbon Monoxide and Barbiturates in Ontario—A 4-Year Survey, 1965–1968

The Toxicology Section of the Centre of Forensic Sciences is the only provincial forensic laboratory in Ontario and thus provides toxicological services for the entire Province in investigations of a criminal or medicolegal nature.

The large number of the carbon monoxide and barbiturate fatalities investigated here has provided a unique opportunity to assess the significance of blood concentrations. The purpose of this report is to record and study the frequency distribution patterns of the lethal blood concentrations of barbiturates and carbon monoxide saturations recorded between 1965 and 1968, inclusive. Effort has been made to limit the compilation of data to those fatalities in which the cause of death had been officially attributed, directly or indirectly, to the toxic agent involved.

Analytical Aspects

Carbon monoxide blood saturations were estimated by the microgasometric procedure of Scholander and Roughton [*1*], using total hemoglobin values determined by a modified method of Wong [*2*], based on a photometric measurement of the total blood iron.

Quantitative barbiturate concentrations were determined by the differential spectrophotometric method of Williams and Zak [*3*], and include all of the 5,5-derivatives of barbituric acid. The specific barbiturates were identified by a combination of thin-layer and gas-liquid chromatography.

A modified version of the Smith desiccation procedure [*4*] was employed for quantitative alcohol determinations and all positive samples were examined qualitatively by gas-liquid chromatography.

Results and Discussion

Carbon Monoxide

Data have been compiled from 304 fatalities of which a great majority (287 cases) involved internal combustion engine exhaust fumes as the source of the gas. In the remain-

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ing cases, the carbon monoxide originated from various gas appliances. Fire fatalities were not included because of the inherent difficulties in associating the fatal outcome solely with carbon monoxide poisoning.

The fatalities were studied under the following categories: whole group, suicides, accidents, presence of alcohol and drugs, and presence of pathological conditions. For each of these categories, a frequency distribution curve of the fatalities with respect to the blood saturation of carbon monoxide (in increments of 5 percent) was drawn. The pertinent information from the curves is summarized in Table 1.

TABLE 1—*Carbon monoxide fatalities.*

Category	Number of Cases	Carbon Monoxide Saturation, %				
		Mean	Standard Deviation (±)	Minimum Maximum	Highest Single Frequency Range, %[a]	Majority Range[b]
Whole Group	304	51.4	12.4	23–89	45–49 (18)	40–59
Suicides[c]	162	53.3	12.2	24–83	50–54 (18.5)	45–64
Accidents[c]	135	49.4	12.0	23–89	45–49 (23.8)	40–59
Presence of Alcohol and Drugs	135	51.5	12.9	24–89	45–49 (16.3)	40–59
Presence of Pathological Conditions[c]	25	46.2	17.3	23–89	35–39 (36.0)	30–44

[a] The highest single frequency range (percentage of fatalities in this range).
[b] The combined highest adjacent frequency ranges which include more than 50% of fatalities.
[c] From information in case files at the office of the Supervising Coroner for Ontario.

The mean lethal percent saturation of carbon monoxide was found to be 51.4 ± 12.4 percent. Saturations of 23 and 24 percent were found in two individuals in the survey; however, both these victims were found unconscious and died approximately 1 h later. The results of this survey, therefore, indicate that for a majority (approximately 68 percent) of the fatalities studied, the blood saturation of carbon monoxide ranged between 39 and 64 percent. This appears to be lower than figures found in the literature [*5,6,7*]. The suicide group showed a somewhat higher mean lethal saturation than the accident group.

The category of fatalities in which alcohol or other drugs were found in addition to carbon monoxide, deserves a closer scrutiny. The drugs involved were mostly alcohol and barbiturates with blood concentrations ranging from traces to possibly lethal values. It was interesting to note that the presence of the drugs had no effect on the mean or the frequency distribution pattern of the lethal carbon monoxide saturations of this group. This work, therefore, gives no evidence of enhancement of the toxicity of carbon monoxide by central nervous system depressants such as alcohol or barbiturates. Although references dealing specifically with this aspect could not be found, these results would seem at some variance with the reports of Maehly [*7*] and Hall [*8*], both of which include intoxication with alcohol or drugs as one of the factors influencing individual susceptibility to poisoning with carbon monoxide.

The last category in Table 1 includes carbon monoxide fatalities in which autopsy findings revealed cardiovascular, respiratory, or severe anemic disorders. The lowered mean lethal saturation and the generally lower distribution pattern in this category would appear to indicate that individuals with such diseases can succumb with lower saturations of carbon monoxide as compared with the whole group. This is in general agreement with the observations of other investigators [*7,8,9*].

Barbiturates

This study has been compiled from 324 fatalities attributed to poisoning either by barbiturates alone or by the combined effects of barbiturates and ethanol. Cases in which drugs other than barbiturates and ethanol were found, or in which the particular barbiturate derivative was not characterized, were excluded from the survey. Only those barbiturates which were found in at least five fatalities were tabulated. The whole group was divided into two categories on the basis of the presence or absence of ethanol and each group was further subdivided according to the type of barbiturate involved. Frequency distribution curves with respect to the barbiturate blood concentration (in ranges of 0.5 mg/100 ml) were constructed for each of the above categories and pertinent information from these curves is tabulated in Table 2.

TABLE 2—*Barbiturate fatalities.*

		Barbiturate Alone Blood Barbiturate Level, mg/100 ml				
	Number of Cases	Mean	Standard Deviation (±)	Minimum Maximum	Highest Single Frequency Range, %[a]	Majority Range[b]
Secobarbital	28	2.8	1.3	1.5–7.4	2.0–2.4 (28.8)	1.5– 2.4
Pentobarbital	25	4.2	2.2	1.8– 9.1	3.0– 3.4 (20.0)	1.5– 4.4
Amobarbital	15	4.3	1.6	1.7– 8.2	4.5– 4.9 (18.7)	3.0– 5.4
Butabarbital	5	3.8	1.1	2.7– 5.9	3.5– 3.9 (40.0)	3.0– 3.9
Phenobarbital[c]	14	11.4	3.6	4.8–19.4	12.5–12.9 (28.5)	10.5–13.4
Amobarbital with Secobarbital, (eg., Tuinal)	72	4.3	2.1	1.6– 9.7	2.5– 2.9 (16.6)	2.0– 4.4
		Barbiturate-Ethanol Combinations[d]				
Secobarbital	37	2.2	1.3	0.6– 5.9	1.5– 1.9 (24.3)	1.0– 2.4
Pentobarbital	20	1.9	0.9	0.7– 4.1	1.0– 1.4 (30.0)	1.0– 2.4
Amobarbital	20	2.8	2.0	0.7– 8.0	1.5– 1.9 (30.0)	1.0– 2.9
Butabarbital	5	2.1	0.5	1.5– 3.9	1.5– 1.9 (60.0)	1.5– 1.9
Phenobarbital[c]	12	4.4	3.2	0.8–10.0	2.5– 2.9 (25.0)	1.0– 5.4
Amobarbital and Secobarbital (eg., Tuinal)	71	2.5	1.8	0.5– 9.9	2.0– 2.4 (21.1)	1.5– 2.9

[a] The highest single frequency range (percentage of fatalities in this range).
[b] The combined highest adjacent frequency ranges which include more than 50% of fatalities.
[c] Epileptic fatalities are not included.
[d] Traces to 550 mg/100 ml of alcohol in blood.

Since the lowest barbiturate concentrations with and without alcohol, have been of particular interest, these are shown in greater detail in Table 3.

In the barbiturate-ethanol category (Table 2), the mean lethal concentrations of all barbiturates were found to be significantly lowered, as compared with the barbiturate-alone group. Together with similar results reported by other workers [*10,11*], these findings clearly illustrate the mutual enhancement of the depressant actions of barbiturates and ethanol. From Table 2, it can also be seen that the effect of ethanol was most pronounced with phenobarbital, and least with secobarbital. This observation agrees with the findings of Wiberg et al [*12*] who concluded from their study of toxicity of ethanol-

TABLE 3—*Selected barbiturate fatalities.*[a]

Barbiturate	Number of Fatalities	Blood Barbiturate Level (mg/100 ml)	Blood Alcohol Level (mg/100 ml)
	Barbiturate-Ethanol		
Secobarbital	4	0.6–0.9	90–190
Pentobarbital	2	0.7–0.9	150–260
Amobarbital	1	0.7	180
Butabarbital	3	1.5–1.7	110–310
Phenobarbital	1	0.8	340
Amobarbital with Secobarbital	4	0.5–0.8	150–210
	Barbiturate Alone		
Secobarbital	7	1.5–1.8	
Pentobarbital	3	1.8–1.9	
Amobarbital	1	1.7	
Butabarbital	2	2.7–2.9	
Phenobarbital	1	4.8	
Amobarbital with Secobarbital	3	1.6–1.7	

[a] The lowest lethal barbiturate concentrations (the lowest single ranges of the respective frequency distribution curves).

barbiturate mixtures in rats, that the most marked ethanol-barbiturate interaction was long-acting barbiturates.

Pharmacologically, one would expect similarity between the short-acting pentobarbital and secobarbital. However, on comparing the two drugs in Table 2, it was surprising to note the considerably higher mean lethal concentration for pentobarbital without ethanol, as well as the relatively greater reduction of this mean in the presence of ethanol.

Summary

Toxicological blood concentration data have been recorded for 304 cases of carbon monoxide and 324 cases of barbiturate fatalities recorded between 1965–1968, in which the cause of death was officially attributed, directly or indirectly, to the toxic agent involved.

The collected data were used to study the frequency distribution patterns of the lethal blood concentrations, and the information obtained was tabulated to contain the mean and the standard deviation values of selected categories including, for carbon monoxide: suicides, accidents, presence of alcohol and drugs, and presence of pathological conditions. Barbiturate fatalities were divided according to the type of the barbiturate involved, as well as on the basis of presence or absence of ethanol.

It is hoped that the results presented in this report together with the information already available, will provide a basis for a somewhat greater degree of confidence in the interpretation of carbon monoxide and barbiturate blood concentrations.

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