

## CASE REPORT

*E. L. Covey,<sup>1</sup> B.S.*

### Death Sequence in Multiple Carbon Monoxide Asphyxiations

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A recent case of multiple carbon monoxide asphyxiations was investigated by authorities and ruled accidental. The question of the sequence of death became a critical issue to the estate settlement.

An experimental approach for providing evidence as to the sequence of death of two of the three victims is described. Other facts revolving about the case are discussed and comparison of the results to previous data is provided. Based on the results of this procedure and autopsy findings, an opinion as to sequence of death could be offered by the medical examiner.

#### **Investigative Procedure**

Conditions of the scene at the time of discovery and investigative efforts on the part of local authorities indicated the following events.

A 42-year-old intoxicated male arrived at his residence in the early morning hours. The male victim activated an automatic garage door opener and drove his 1972 full-size automobile into the garage; he then placed the automobile in "park" and closed the garage door by once again using the remote control device. Sometime after this point, while remaining in the vehicle, he became unconscious. The automobile's engine was still running, all the windows were rolled up, and the headlights were left on.

The two-car garage was located directly beneath the three bedrooms of the family dwelling, each of which was occupied.

A 32-year-old female, wife by second marriage to the adult male victim, was sleeping in the north bedroom. An 18-year-old female, daughter by first marriage to the adult male victim, was sleeping in the southeast bedroom. A 5-year-old male, son to the adult male by second marriage, was sleeping in the south central bedroom.

Death occurred to the husband, wife, and daughter, with the five-year-old son surviving. Cause of death was confirmed as carbon monoxide asphyxiation in all three victims, who were in otherwise apparent health.<sup>2</sup>

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<sup>1</sup>Chief forensic chemist, Regional Criminalistics Laboratory, Metropolitan Kansas City, Independence, Mo. 64050.

<sup>2</sup>B. J. Peterson, Jackson County medical examiner, Kansas City, Mo., personal communication.

### Death Sequence

Estate settlements would be dictated by the death sequence between the husband and wife. The prospective recipients were the wife by the first marriage and the surviving son by the existing second marriage.

Evidence as to death sequence between the husband and wife was sought by the medical examiner to corroborate autopsy findings. Sequence of death between the two victims in question could be indicated provided the exposure to the carbon monoxide was much more acute for one victim than the other.

Through scene photographs taken at the time of discovery of the accident and interviews with local police and relatives, the internal conditions of the residence at the time of the deaths were reconstructed. None of the rooms in question had been significantly altered; however, attention was drawn to door positions, exact body positions, and room temperature. The doors of the north and southeast bedrooms were completely closed while the door of the south central bedroom was open. The windows in each of the bedrooms were closed. These conditions were reproduced during the test. The automobile involved in the incident, a 1972 Chevrolet Impala with a 6400-cm<sup>3</sup> (400-in.<sup>3</sup>), eight-cylinder engine, was still in its original position. The automobile required only a battery charge and additional fuel. Nineteen litres (five gallons) of a regular leaded gasoline was introduced to assure a sufficient run time. Other conditions of the vehicle that were reproduced included all windows in the rolled-up position, the heater-fan in the low speed setting, and the headlights on.

### Sample Collection

Atmospheric samples were drawn by mechanical pump to a collection station outside the dwelling via plastic tubing 9 m (30 ft) long with an inside diameter of 6.0 mm. After being purged for 1 min the air flow within the tube was sampled into a rubber-stoppered 100- by 13-mm evacuated glass vessel by means of a hollow transfer needle. The mechanics of this mode of sample collection allowed a sample to be drawn every 2 min.

Four locations were monitored within the dwelling corresponding to the positions of each of the victims and survivor. The sample tubing was placed at the positions of each victim's head as indicated by the scene photographs to allow representative samples of what the victims would have respired. Sample collection was initiated 4 min after the automobile was started and immediately after the garage door was lowered. The four areas were sampled in continuous rotation, beginning with the automobile's interior and followed by the north bedroom, the southeast bedroom, and the south central bedroom.

Samples were drawn for 60 min, yielding six samples from each location at 10-min intervals.

### Analysis

The atmospheric samples were taken immediately to the laboratory for analysis for carbon monoxide by gas chromatography.

The instrument employed was a Perkin-Elmer 900 with a thermal conductivity detector and helium as the carrier gas. The 1.8-m (6-ft) column was 6.35-mm (0.25-in.) outside diameter glass packed with molecular sieve 5A 60-80 mesh operated isothermally at 50°C, with a carrier gas flow of 20 cm<sup>3</sup>/min. The thermal conductivity detector was set at 200°C and 275 mA. The injector temperature was 150°C.

Samples of 0.25 cm<sup>3</sup> were withdrawn from the glass collection vessels and injected into the chromatograph with a gas syringe. The resulting chromatographic separation of oxygen, nitrogen, and carbon monoxide is shown in Fig. 1.<sup>3</sup>

<sup>3</sup>K. Carle, Specialty Gases Dept., Linde Div., Union Carbide Corp., East Chicago, Ind. 46312.

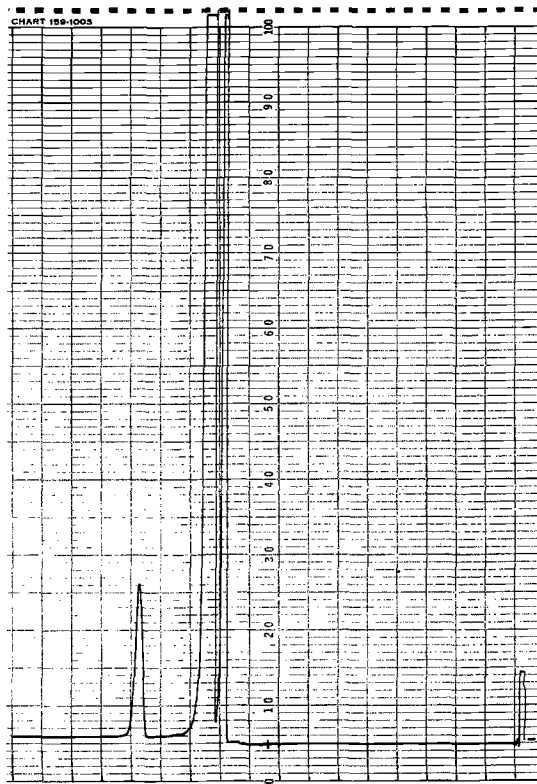


FIG. 1—Gas chromatographic separations of oxygen, nitrogen, and carbon monoxide with a molecular sieve, 60–80 mesh, at 50°C. Chart speed is 30 s/division.

Standards were obtained commercially from Air Products and Chemicals Inc. as certified concentrations of carbon monoxide in nitrogen. These concentrations were 0.11, 0.29, and 0.69%. Sampling and analysis of these standards were conducted in the same manner as the unknowns. A calibration curve was prepared for use in determining the concentration of carbon monoxide in the test samples.

### Results and Discussion

The atmospheric concentration of carbon monoxide versus time is provided in Fig. 2. This format allows a profile to be drawn that reflects the exposure of each person in the dwelling to the poisonous gas.

The collection of samples was discontinued at 60 min because the automobile engine failed at 56 min by overheating.

The build-up of carbon monoxide in the automobile was abruptly more acute as compared to the other positions. The atmospheric profiles of the bedroom positions, while much lower than the automobile, do reflect potential atmospheric concentrations to cause death, as seen in Table 1 [1]. It should be further noted that concentrations of carbon monoxide in the bedrooms occupied by the wife and the daughter were too close to indicate any difference in time of death.

The rather close profile uniformity of the bedroom positions tends to discount any stratification by the carbon monoxide emissions. Thermal stratifications of carbon monoxide can exist but are temporary as its density is approximately that of air [2].

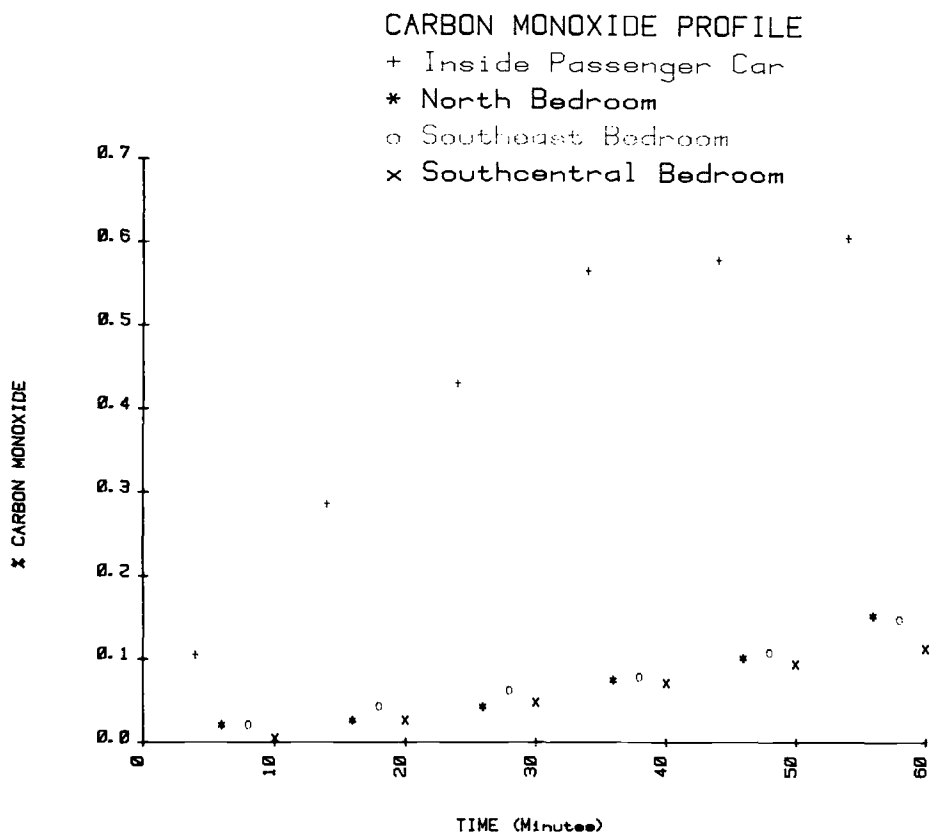


FIG. 2—Percent atmospheric carbon monoxide versus time in minutes of the four positions monitored during reenactment of the accident.

The affinities with hemoglobin exhibited by carbon monoxide and other physiological considerations are well documented and beyond the scope of this communication [19]. From a pathological point of view all three victims could be considered adults in their tolerances to carbon monoxide. However, any central nervous system depressant such as alcohol would be an additional factor to consider because such depressants lower the threshold of toxicity, making the individual less tolerant [39]. The blood alcohol level of each victim is provided in Table 2.

The five-year-old male in the south central bedroom survived asphyxiation but exhibited symptoms of moderate carbon monoxide poisoning. He said he left the bedroom and moved about other areas of the house. He was also observed walking about the yard by neighbors in the early morning hours. This activity could have provided the necessary

TABLE 1—Hemoglobin saturation by carbon monoxide [1].

Atmospheric Carbon Monoxide, %	Carboxyhemoglobin, <sup>a</sup> %
0.01	17
0.02	20
0.10	60
1.00	90

<sup>a</sup> Blood-gas equilibrium is attained in 1 to 4 h.

TABLE 2—*Blood-alcohol analysis.*

Victim	Age, years	Carboxy-hemoglobin, <sup>a</sup> %	Blood Alcohol, %
Male (deceased)	42	69	0.240
Female (deceased)	32	59	0.000
Female (deceased)	18	57	0.000
Male (survivor)	5	N/A	N/A

<sup>a</sup> Spectrophotometric determination (Footnote 2). N/A = not applicable.

relief from the carbon monoxide. Additionally, the south central bedroom was the only bedroom with the door open, which would allow faster dissipation of any buildup of carbon monoxide after the automobile stopped running.

The remaining two bedroom doors were closed at discovery of the accident, indicating no activity by the two females outside the rooms. No evidence to the contrary was present.

### Summary

Potential variables to this particular instance did not apply and a good representative reconstruction of the accident was possible. The variable of activity by the victims during the incident was limited and confined to individual, "closed" quarters. The same automobile was employed; it had not been in use at all during the interim period. This fact is particularly important since automotive emission of carbon monoxide can reach a level of 30%; however, the more common emission has been reported at 7% [4]. The heater system of the automobile was on with the blower on the lowest speed.

The reconstruction of the accident through scene photographs and interviews of relatives and other personnel provided a basis for supplemental findings to the medical examination and allowed an opinion to be drawn by the medical examiner that the husband died before the wife.

Feasible explanations for the five-year-old child surviving essentially the same carbon monoxide exposure as the two female victims were provided.

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Address requests for reprints or additional information to  
E. L. Covey  
Regional Criminalistics Laboratory  
Metropolitan Kansas City, Mo.  
Independence, Mo. 64050