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CASE REPORT

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Suicidal Asphyxiation by Inhalation of Automobile Emission without Carbon Monoxide Poisoning

ABSTRACT: Reported herein is the suicidal asphyxiation of a young man due to exhaustion of oxygen in the interior of a sealed automobile into which the exhaust emissions were diverted. His blood carboxyhemaglobin concentration was less than 5% saturation. The car was equipped with a catalytic converter and when tested, the exhaust carbon monoxide concentration was 0.01%.

KEYWORDS: forensic science, automobile exhaust-inhalation, carboxyhemoglobin, asphyxiation, suicide

When the exhaust emissions of an automobile are diverted into the sealed interior compartment, the gaseous atmosphere of the interior is inevitably altered. The new gaseous makeup will depend upon the emissions from the vehicle, but invariably will increase the carbon dioxide (CO_2) concentration, and decrease the oxygen (O_2) concentration, and consequently produce an atmosphere which causes an asphyxial event due to insufficient O_2 to maintain critical metabolic needs. If the setup is relatively airtight, the accumulation of CO_2 and lack of O_2, even without harmful carbon monoxide (CO) concentration, can lead to unconsciousness and death, which may result after 50% of the atmospheric O_2 is displaced by other gases (1–3).

Case Report

A 17-year-old man was discovered lying on his left side in the driver's seat of his 1997 BMW which was parked in a wooded area several miles from his home. The automobile engine was running. One end of a pool hose was connected to the exhaust pipe; the other end entered the interior of the vehicle through the driver's side rear window. Pieces of cloth were used to seal the open window gap. The vehicle was locked and the fire department gained access by breaking a window. Several hand written suicide notes were found in the car.

At autopsy fixed purple lividity and Tardieu spot distribution were consistent with the position in which he was found. The abdomen was distended with gas and there were patchy areas of skin slippage. He had neither physical injury nor natural disease. Standard toxicology testing was negative for ethanol, opiates, benzodiazepines, and basic drugs. His blood carboxyhemoglobin (COHb) was less than 5% saturation. Subsequent testing of the automobile emissions revealed that the CO was consistently 0.01% and the CO_2 varied between 14.9% and 15.2%. His cause of death was attributed to asphyxiation due to exhaustion of O_2 in the interior of the car due to instilled exhaust fumes.

Discussion

When a person is found dead in an automobile in which the exhaust fumes have been diverted into the cab of the vehicle, it is assumed that they have succumbed to CO poisoning, because CO is the most toxic component of motor vehicle exhaust, resulting from the incomplete combustion of carbon containing fuels.

In a 1965 article, McBay (1) pointed out that the exhaust of gasoline engines may produce up to 7% CO. He also stated that the exhaust will saturate the interior of a small garage in 15–30 min with a lethal concentration of CO. With an atmospheric concentration of 1% CO (10,000 p.p.m.), a lethal quantity may accumulate in the blood in less than 10 min. It takes only 570 p.p.m. of atmospheric CO to produce 50% COHb.

The U.S. Federal government enacted legislation in 1968 requiring the utilization of exhaust emission controls on automobiles, prompted by the need to diminish air pollution. New vehicles were required to be fitted with devices which remove, or greatly reduce, the levels of toxic agents in exhaust gases, particularly hydrocarbons, nitrogen oxide, and CO (4).

In order to comply with Environmental Protection Agency standards, the first catalytic converters were introduced for automobile use in the U.S. in 1975. The catalytic converter, located between the engine block and the muffler, is comprised of a meshwork of ceramic material (coated with rhodium and platinum, the catalysts) that increases the surface area for oxidation or burning of the hydrocarbons and CO after they leave the engine, thereby accelerating the conversion of the products of incomplete combustion to fully oxidized water and CO_2 (5–7).

Newer cars may emit at idle an exhaust containing less than 0.1% CO. The decrease from preemission control to this level is close to two orders of magnitude (7). Lester et al. (8) showed that the accidental death rate from car exhaust in the U.S. declined after 1968. During 1968–1998, the U.S. annual rate of nonfire-related CO poisoning deaths declined by almost 60%, partly related to reduced CO emissions from automobiles (9). As motor

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vehicle exhaust in the U.S. has become less toxic, it appears that fewer individuals have utilized it as a means of suicide (4,10).

Because a well-functioning catalytic converter eliminates more than 90% of CO emission, Morgan et al. (3) stated that in theory, it is impossible to commit suicide by CO poisoning with a vehicle equipped with a catalytic converter. However, at the cold start of an engine, an excessive amount of fuel is necessary to initiate the combustion process. The catalytic converter is dormant for a short time after start-up in order to ensure initiation of the combustion process. The "warm up time" is an expression of the time it takes the engine and catalytic converter to achieve a certain operating temperature. The high loads and engine speeds of a recently running vehicle allow a short warm-up time, while idling from a cold start yields a longer warm-up time, resulting in a longer delay to catalytic converter initiation. The CO level is therefore higher during a cold start than when the engine has been running for a period of time or is started warm. Therefore, exhaust CO steadily declines from cold start to warm-up (3,11). Because of this, Morgan et al. (3) were able to demonstrate experimentally that it was possible to commit suicide by CO poisoning using a car equipped with a catalytic converter if started cold or if the catalytic converter was not functioning optimally. They showed that the peak CO concentrations in the cabin occurred soon after starting a cold engine, at which time it is two to three times the final constant values. It is more difficult to commit suicide using car exhaust when the catalytic converter is functioning well and the engine is started warm. In the case reported here the vehicle was discovered in a wooded area several miles from the decedent's home. This suggests that the engine was already warm at the time of the incident, thus lowering the concentration of CO in the diverted exhaust.

There are several reports in the literature of people who survived between one to several hours of automobile exhaust exposure in confined spaces, either in a closed garage with a running automobile or within the interior of vehicles into which the exhaust was diverted into the occupant compartment. All of the automobiles in these cases were fitted with catalytic converters and had low emissions (5,6,12–14).

As in the case reported here, Atkinson et al. (2) reported on a man found dead in his car. A hose led from the exhaust into the vehicle and the engine was still idling. His COHb concentration was less than 5% saturation. The car was fitted with a catalytic converter. Schmunk et al. (11) also reported on two people found dead, a man in his running automobile (with the exhaust diverted into the cab) and a woman in a closed garage with an idling automobile. The man's COHb was less than 10% and the woman had a negative COHb. The causes of death were attributed to inhalation of the products of combustion. They stated that the primary cause of death in both cases was inhalation of toxic levels of CO_2. The associated depletion of O_2 contributed to death by asphyxiation. Of note, Atkinson et al. (2) also described a man who was found dead in his car after he discharged two CO_2 gas cylinders inside the vehicle.

There are several reports in the literature of individuals who have survived exhaust fume exposure from low emission vehicles in confined spaces (5,6,12–14). Despite automobiles having been equipped with catalytic converters for several decades, there are few reported fatalities from asphyxiation due to depletion of O_2 or CO_2 narcosis, resulting from exposure to low emission fumes in confined spaces, with negligible CO blood saturation. Such scenarios therefore require complete scene investigation and autopsy, including full toxicology analysis to exclude other causes of death. Forensic pathologists need to be aware of this entity in order to avoid interpreting such fatalities as staged suicides intended to conceal a more sinister cause and manner of death.

References

1. McBay JA. Carbon monoxide poisoning. N Engl J Med 1965;272: 252–3.
2. Atkinson P, Langlois NEI, Adam BJ, Grieve JHK. Suicide, carbon dioxide, and suffocation. Lancet 1994;344:192–3.
3. Morgan C, Schramm J, Kofoed P, Steensberg J, Theilade P. Automobile exhaust as a means of suicide: an experimental study with a proposed model. J Forensic Sci 1998;43(4):827–36.
4. Clarke RV, Lester D. Toxicity of car exhaust and opportunity for suicide: comparison between Britain and the United States. J Epidemiol Community Health 1987;41(2):114–20.
5. Landers D. Unsuccessful suicide by carbon monoxide: a secondary benefit of emissions control. West J Med 1981;135(5):360–3.
6. Wagg AS, Aylwin SJ. Catalytic converter and suicide risk. Lancet 1993;342:1295.
7. Shelef M. Unanticipated benefits of automotive emission control: reduction in fatalities by motor vehicle exhaust gas. Sci Total Environ 1994;146–147:93–101.
8. Lester D, Clarke RV. Effects of the reduced toxicity of car exhaust on accidental deaths: a comparison of the United States and Great Britain. Accid Anal Prev 1989;21(2):191–3.
9. Mott JA, Wolfe MI, Alverson CJ, Macdonald SC, Bailey CR, Ball LB, et al. National vehicle emissions policies and practices and declining us carbon monoxide-related mortality. JAMA 2002;288(8):988–95.
10. Clarke RV, Lester D. Detoxification of motor vehicle exhaust and suicide. Psychol Rep 1986;59(3):1034.
11. Schmunk GA, Kaplan JA. Asphyxial death caused by automobile exhaust inhalation not attributable to carbon monoxide toxicity: study of two cases. Am J Forensic Med Pathol 2002;239(2):123–6.
12. Hays P, Bornstein RA. Failed suicide attempt by emission gas poisoning. Am J Psychiatry 1984;141(4):592–3.
13. O'brien JT, Tarbuck AF. Suicide and vehicle exhaust emissions. BMJ 1992;304:1376.
14. Vossberg B, Skolnick J. The role of catalytic converters in automobile carbon monoxide poisoning. Chest 1999;115:580–1.

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