AN OVERVIEW OF CARBON MONOXIDE DEATHS IN KUWAIT BETWEEN YEARS 2013-2019 WITH FOUR RARE CASES PRESENTATION: A FORENSIC PRACTITIONER EXPERIENCE.

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ABSTRACT

Background: Carbon monoxide (CO) is an odourless, colourless, non-irritating, highly toxic gas produced after the incomplete combustion of hydrocarbons.CO; forms carboxyhemoglobin (COHb), which will lead to severe tissue hypoxia and death in some cases. **Subjects and Method**: In the present study, we will discuss the most typical causes of deaths due to CO toxicity in Kuwait between the years 2013-2019 from the perspective of a forensic medicine practitioner in the Forensic Medicine Department in the General Administration for Criminal Evidence – Ministry of Interior- Kuwait. Additionally, we present a rare accidental death of four cases (2 male and female partners) handled in 2015 and 2016 in the Forensic Medicine Department. Each couple was found dead in a car parked in an open space, and the lethal levels of COHb were detected in their blood. **Results and conclusion**: Between the years 2013 and 2019, in every 100 cases of yearly unnatural deaths in Kuwait, there were 1-3 cases of CO poisoning-related deaths (1-2%). The ages ranged from 9 months until 81 years. The range of the COHb concentration in the blood sample was from 36.5% to 80%. The most common cause was smoke inhalation in fires (60%). Defective coal stove was a less common event, which is believed to occur only during winter months (20%). As a result, the presentation of four autopsies of cases found dead in closed cars in open spaces, after accidental lethal CO inhalation, was worth mentioning. After expert examination, both cars showed defective engines where the CO level increased inside the cabinet. This led to the death while the cars were parked in an open land. These cases are worthwhile reporting being rarely described in forensic toxicology.

Keywords: carbon monoxide, Kuwait, poisoning, defective interior vehicles, carboxyhemoglobin, open space.

INTRODUCTION

Deaths of CO poisoning in forensic practice globally are either suicidal or accidental **(Susan et al., 1972)**. The most common method for suicidal CO toxicity is to connect the exhaust pipe of the vehicle with the interior of the vehicle using a garden hose or a vacuum cleaning tube. On the other hand, it is well known that there are accidental deaths when a car is being repaired or used in a garage or a closed space **(Kumazawa et al., 2000)**. Faulty household heating appliances have caused most of the accidental CO poisoning. Propane-fuelled forklifts, gas-powered concrete saws, indoor tractor pulls, inhaling spray paint, and swimming behind a motorboat are all CO toxicity sources. Other CO sources are industrial steel foundries, pulp mills, formaldehyde-producing plants or coke **(Nnoli, 2009)**. CO intoxication also occurs by inhaling methylene chloride vapors, a volatile solvent, paint removers, and degreasers (**Prockop and Chichkova, 2007)**.

Carbon monoxide poisoning clinical signs and symptoms ranges from headache, nausea, vomiting, dizziness, and syncope to

weakness, tachycardia, and tachypnea (**Ashry et al., 2018)**. Before death, severe palpitations, hypotension, cardiac ischemia, pulmonary edema, and seizure occur which, usually lead to cardiac and respiratory arrest (**Louise and Kristine, 2006)**.

The deaths in Kuwait are usually categorized as natural or unnatural deaths. Natural deaths are those who die as an expected result of their health status without any unexpected or accidental event. Meanwhile, unnatural deaths are the deaths that occurred after a criminal or accidental event. Criminal deaths were those whose death occurred after a deliberate act by others or by themselves (suicide and deliberate self-harm).

SUBJECTS AND METHODS

A retrospective study was done on the cadavers referred to the Forensic Department in General Administration for Criminal Evidence – Ministry of Interior-Kuwait. The study included 44 cases referred between the years 2013 and 2019. Variables related to age, sex, level of CO% in blood, and the source of the CO were analyzed. Before blood specimen analysis, they were left to equilibrate at room temperature (23–25 ◦C) for 15 min. After that, the sample was thoroughly mixed for at least 15 s and analyzed immediately. A 150 µL of the blood specimen was used. It was collected in a syringe and introduced into the analyzer by aspiration. Any clots or bubbles in the syringe were removed. The GEM® Premier™ 4000 provides complete quantitative analysis, up to 21 parameters, within 95 s. For the CO-oximetry analysis, the sample was chemically hydrolyzed and placed in an optical cell to measure light absorption using a broad-spectrum (475–650 nm) spectrometer. The outputs included measurements of the levels of total Hb, oxygen carrying Hb, COHb along with methemoglobin in each sample. Analysis of results was done and demonstrated in charts and pies to present the many results of this work. Additionally, the presentation of a less common source of fatal CO levels in the community highlighted other possible circumstances. This was presented in rare cases of accidental CO poisoning that occurred in 2015 and 2016.

RESULTS

This study was conducted among a group of CO-related deaths in Kuwait whose age ranged from 9 months up to 81 years. Forty-four cases were examined in the Forensic Department, which is the only Forensic Medicine department in the state. This study showed that about two-thirds of CO toxicity (26 cases) occurred with smoke inhalation in household fires (60%). Meanwhile, heating stoves in cold months caused most of the remaining (9 cases) CO deaths (20%). Other causes reported in 9 cases (20%) were faulty automobiles engine, automobile fires, and agricultural fires (fig.1).

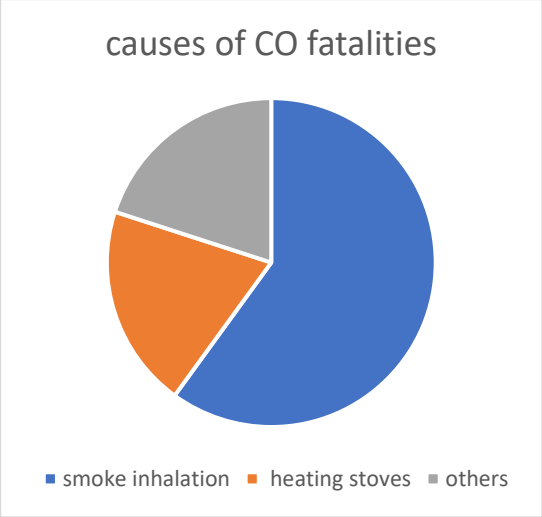

Figure (1): causes of CO deaths.

Out of 44 cases, 16(36.3%) cases had a COHb level of about 72.6%; however, 12 cases (27.2%) had a COHb of 57.7%. In 8 (18.1%) cases, the COHb level was 48%. Equally, 4 cases (9.2%) had a COHb level of 36.5% or above 80% (fig.2). Cherry red coloration mainly was observed with COHb concentrations exceeding 30 %.

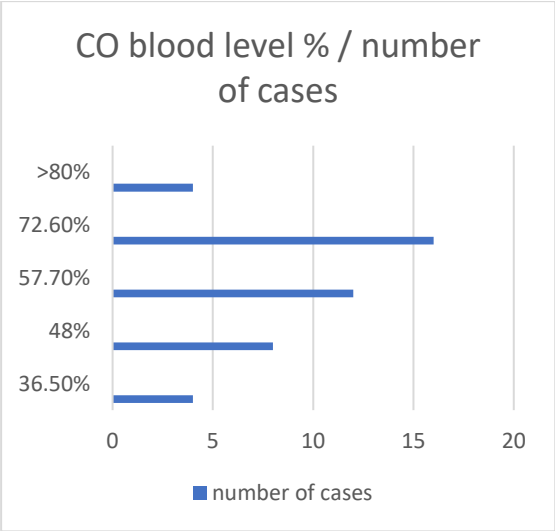

Figure (2): level of COHb level against the number of cases.

Regarding the age of CO toxicity deaths, 12 cases (27.3%) were around the age of 40 years, and this presented the highest rate. However, cases above 60 years were only 4 (9%). Those below 15 years were about 5 cases (11.3%) and, around the age of 20, there were 11 cases (25%). Around the age of 30, and 50, there were 6 cases each (13.6%) (fig.3).

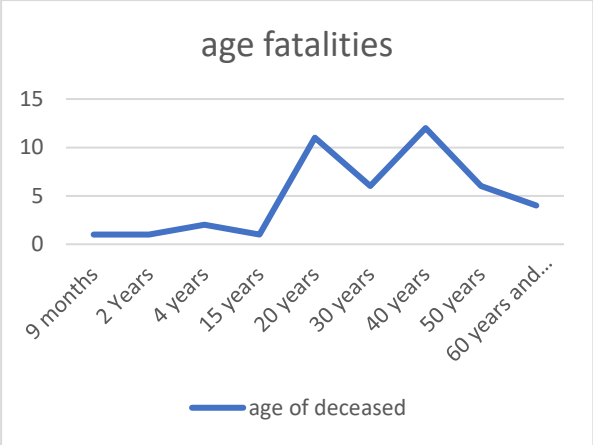

Figure (3): the age presentation of the deaths.

CO toxicity deaths were around 3% of unnatural deaths in the years 2016 and 2017, 2% in the years 2014,2015, and 2018 but, only 1% in the years 2013 and 2019 (fig.4).

The total number of unnatural deaths was 315 cases. Out of this, CO-related deaths were 4 cases in 2013, 6 in 2014 and 2018, 7 in 2015, 9 in 2016 and 2017, and 3 cases in 2019.

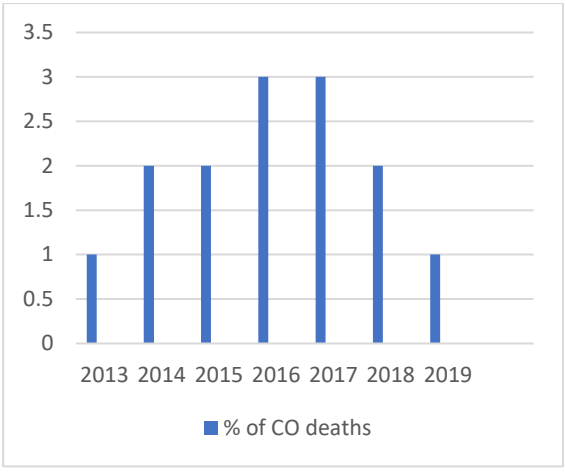

Figure (4): %CO deaths in total deaths over 2013-2019.

Regarding the relation between the level of the COHb in blood and the deceased's age, the lowest levels were in the extremities of age. COHb was 36.5% in infants below one year, and around 41% in those above 70 years. On the other hand, COHb was recorded up to 80% in ages ranging between 30 and 49. Below the age of 20, it was around 45.6%, and in ages, up to 29, it was about 62.7%. Between the age of 50 and 69, COHb was about 76.5% (fig.5).

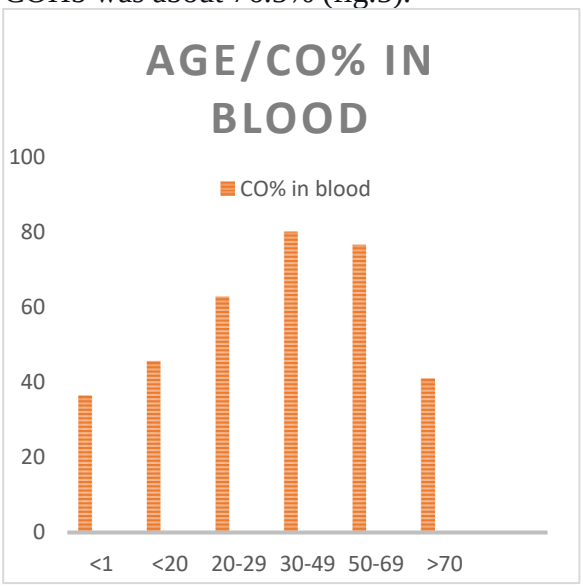

Figure (5): the age limit against COHb level.

Regarding the sex, 15 cases out of the 44 were males (34%), and the rest were females (66%). However, the source of the CO, COHb level in the blood, and the age range of cases were similar in both sexes.

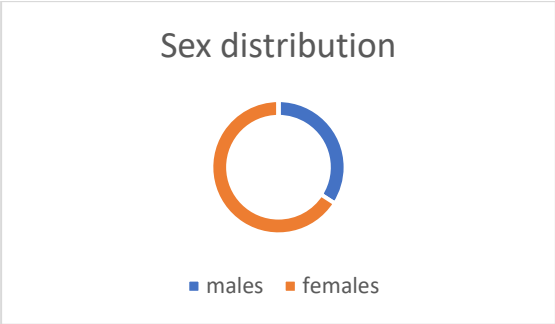

Figure (6): the sex distribution in COHb-related deaths.

DISCUSSION

In 2020, Attaia et al. mentioned in their study, which was done on deaths in Alqurayyate in Saudi Arabia from years 2004 to 2018, that smoke inhalation in fires was the most prevalent manner in CO inhalation related deaths **(Attaia et al., 2020).** Similarly, in 2012 and 2020, Algoet et al. and Kinoshita et al. respectively have reported, that house fires were the most common cause of CO mortalities in Europe (**Algoet et al., 2012 and Kinoshitaa et al., 2020**). Between the years 2014 and 2018, a study in Kuwait presented that household fires caused 61% of the deaths and coal stoves caused 22% (**Al-Matrouk et al., 2021**). These results were close to what we presented in this study which showed that household fires were the leading cause.

The level of the COHb in blood in post-mortem examination showed a wide range. The fatal level of CO-Hb saturation is usually over 50–60 % (**Suzuki and Watanabe 2005**). The average of COHb level in deaths in Kuwait was in an average of 66% 4. The level of 72.6 % of COHb was the most measured in the deaths in this study. However, up to 81% of COHb was measured as well. The least measured COHb in this study was 36.6% found in a nine-month-old infant. The level of COHb is usually affected by many factors, such as the concentration of inspired CO and the duration of CO exposure (**Inokuchi, 2008**).

The age of the fatalities was mainly between the ages of 20 to 50. Can et al. have stated that the average age of CO deaths in Turkey was around 50 to 16 **(Can et al., 2019)**. In 2020, Attaia et al. stated that the most COHB deaths was between 30 and 50 years in Alqurayyate in Saudi Arabia **(Attaia et al., 2020).** Both age extremities were the least reported in a study done in Iran for COP **(Hosseininejad et al., 2017).** In the elderly population, more comorbidities may lead to CO-related deaths as it was believed to exacerbate cardiopulmonary diseases even in low levels of exposure **(Hinderliter et al., 1989).**

COHb level was detected in high levels in ages above 20 years and those below 70 years. Meanwhile, it was recorded in the lowest levels in those out of the mentioned age limit. This means that those in extremities of the age line had severe consequences on lower levels of COHb in their blood. Elderly Patients with coronary artery disease showed health effects at lower levels of COHb concentrations than children, females, or young, healthy adults and constituted the most susceptible subpopulation in a study done by Hinderliter et al. **(Hinderliter et al., 1989)**. Klasner et al. pointed out that children tend to be more susceptible to CO toxicity than adults because they breathe a more significant amount of air per body weight than adults **(Klasner et al., 1998).** Apart from that, the cases in the current study have been highest in the years 2016 and 2017, when they represented around 3% of the unnatural deaths. As the household fires were the most recorded cases of CO-related deaths, it was difficult to get a definite correlation between the level of CO-related deaths and the studied years. Additionally, mass deaths in household fires, as in multi-story buildings, could be misleading in this calculation.

Unusual accidental deaths from CO toxicity are not uncommon. There have been reported cases with unexpected circumstances. Such as the case presented by Chand in 2014, where the death occurred in an open garage. **(Chand, 2014).**

CASES PRESENTATION

Case 1,2:

In April 2015, a previously healthy 22-year-old female and a 21-year-old male were dead inside a parked car on the street early morning. The windows and the doors of the car were tightly closed. The car and the air conditioning were left on (fig 7). Both bodies were lying on their backs, with a naked lower half, and covered with vomitus inside the car. No signs of violence were detected on the scene. On external examination, rigor mortis was formed entirely all over the bodies. Cherry red hypostasis was observed on the back and the dependent parts of the body in supine position, along with fingers cyanosis (fig 8,9,10). Additionally, no signs of physical violence were found. On autopsy, there was marked brain and lungs congestion with frothy tracheal secretions and cherry red discolouration of all tissues suggestive of carbon monoxide toxicity (fig 11,12).

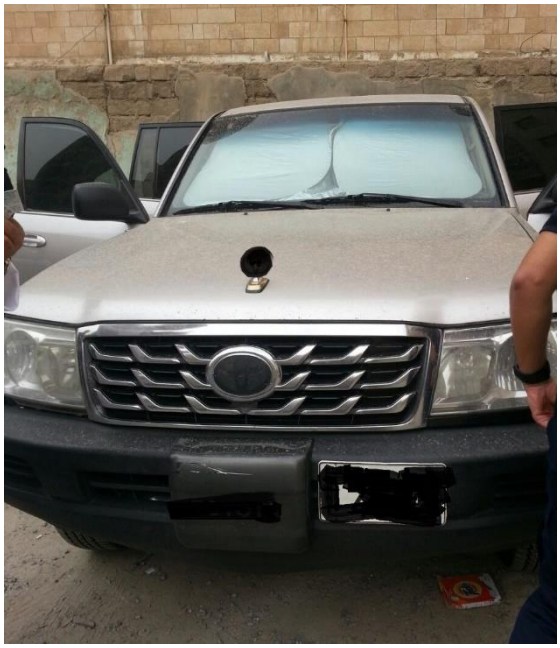

Figure (7): Car parked outdoor.

Figure (8): finger cyanosis and cherry red hypostasis in the male hands.

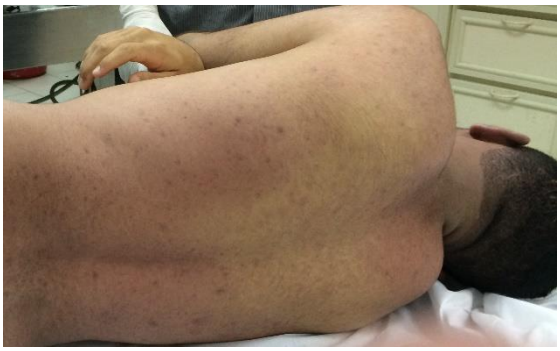

Figure (9): cherry red hypostasis for the deceased male.

Figure (10): cherry red hypostasis for the deceased female

Figure (11): brain of the deceased female with cherry red congestion.

Figure (12): lungs of the deceased female with cherry red congestion and petechial haemorrhages.

Toxicology workup was negative, and neither ethyl nor methyl alcohol was found in the blood samples taken from both. Carboxyhaemoglobin level was 72.2% in the female blood sample while 78% in the male sample. The crime scene and the forensic pathology reports showed that the cause of the death was cardiac and respiratory arrest after the accidental exposure to lethal amounts of CO gas in a secure place. The vehicle inspection by experts showed a defective engine where CO levels accumulated inside the car, especially with the air conditioner on and the windows are tightly closed.

Case 3, 4:

In April 2016, a 36-year-old female and a 39-year-old male, both known as healthy adults, were found dead inside a parked car late at night in the middle of the desert. The windows and the doors of the car were tightly closed. The car and the air conditioner were left in the on mode; however, the car was free of fuel at that time. Bodies were found in a putrefaction state, naked and lying on their backs. The death was believed to occur about 48 hours before the discovery. No signs of violence were suspected on the scene. On external examination, putrefaction had covered entirely the male body (fig. 13-15) and partly started to cover the female (fig. 16-18). Cherry red hypostasis was observed on the dependent parts of the body and peripheries, along with fingers cyanosis. Additionally, no signs of physical violence were found. Nostrils and the mouth opening were covered with bloody fluids. On autopsy, there was marked brain and lungs congestion with severe pulmonary hemorrhage and cherry red discoloration of all tissues suggestive of carbon monoxide toxicity.

Figure (13): deceased male showing putrefaction with cherry red hypostasis on foot.

Figure (14): bloody fluids from nostrils

Figure (15): deceased male showing cherry red hypostasis on the back.

Figure (16): deceased female hand showing cyanosis.

Figure (17): bloody fluids from nostrils and cyanosis of the lips.

Figure (18): deceased female feet with cherry red hypostasis.

Additionally, this study has lightened the dangerous levels of CO inside the defective vehicles, which have led to the death of the occupants. In 2013, Silva et al.; stated that high carboxyhaemoglobin level was detected in workplace accidents in taxi drivers **(Silva et al., 2013).**

CONCLUSION

The current data shows that COP remains a direct cause and a contributing cause of death whatever the safety precautions and the advance in mechanical engineering to eliminate its production from the engines and appliances. Additionally, the inevitable worldwide household fires and faulty heating appliances and cars are the most described sources of fatal CO levels.

RECOMMENDATIONS

The public awareness regarding carbon monoxide toxicity, and its sources is still deficient, and more informative programs should be provided, mainly before winter. COHb levels should be routinely estimated in the autopsied cases with suggestive history. This should not mislead the forensic examiner, and he should ask for COHb levels in COP suspicious cases. Uncommon causes of fatal CO levels must be considered as well. Public, as well as medical awareness, will be in the interest of avoiding such tragedies in the future.

Legend of tables

Table (1): CO related deaths summary according to age, CO source, COHb level, age, CO deaths % , age and COHb % level and sex distribution.

Parameter			Number of cases	%
Age	9 M – 81 Y			
CO source	smoke inhalation in household fires		26	60%
	heating stoves in cold months		9	20%
	faulty automobiles engine, automobile fires and agricultural fires		9	20%
COHB level	72.6%		16	36.3%
	57.7%		12	27.2%
	48%		8	18.1%
	36.5%		4	9.2%
	>80%		4	9.2%
Age of deaths	40 Y		12	27.3%
	>60 Y		4	9 %
	<15 Y		5	11.3%
	Around 20 Y		11	25%
	Around 30Y		6	13.6%
	Around 50 Y		6	13.6%
%CO deaths in total unnatural deaths over the years 2013-2019	2016-2017		9	3%
	2014 and 2018		6	2%
	2015		7	2%
	2013		4	1 %
	2019		3	1%
The relation between COHb level in blood and the age of the deceased	36.5%	< 1Y	-	-
	41 %	>70Y	-	-
	Up to 80%	30-49Y	-	-
	45.6%	<20Y	-	-
	62.7%	Up to 29Y	-	-
	76.5%	50-69 Y	-	-
Sex	Male		15	34%
	Female		29	66%

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الملخص العربي

نظرة عامة على وفيات أول أكسيد الكربون في الكويت بين عامي 2013-2019 مع عرض أربع حالات نادرة: تجربة لممارس الطب الشرعي.

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أول أكسيد الكربون هو غاز عديم الرائحة وعديم اللون شديد السمية ينتج بعد الاحتراق غير الكامل للهيدروكربونات. على الصعيد العالمي، السبب الأكثر شيوعًا للتسمم العرضي بأول أكسيد الكربون هو حرائق المنازل غير المنضبطة ومواقد الفحم للتدفئة في الشتاء وسبب آخر مهم يعود عادة إلى عادم السيارات المتواجدة في مكان مغلق وهو ما قد يستخدم ايضا كوسيلة من وسائل الانتحار. العدد الكبير من الوفيات بسبب المستويات المميتة من أول أكسيد الكربون التي تدخل مقصورة الركاب بسبب عيوب في السيارات الداخلية أصبح مقلق. منهج الدراسة: سنناقش في هذه الدراسة خبرة ممارس الطب الشرعي في إدارة الطب الشرعي بالإدارة العامة للأدلة الجنائية بدولة الكويت في الأسباب الأكثر شيوعاً للوفيات بسبب تسمم أول أكسيد الكربون في الكويت بين الأعوام 2013-2019. بالإضافة إلى ذلك، فإننا نقدم حالات وفاة عرضية نادرة لأربع حالات حدثت في عامي 2015 و2016 حيث تم العثور على كل من الجثث داخل سيارة مغلقة بإحكام أثناء تشغيل المحرك والمكيف ومتوقفة في مكان مفتوح. النتيجة والاستنتاج: بين الأعوام 2013-2019، في كل 100 حالة وفاة غير جنائية تحدث سنويًا في الكويت، كانت هناك 1-3 حالات تسمم عَرَضي بأول أكسيد الكربون (1-2٪). وتراوحت الاعمار من 9 شهور حتى 81 عاما. تراوح نطاق تركيز أول اكسيد الكربون في عينة الدم من 36.5٪ (في أصغر ضحية) إلى 80٪. كان السبب الأكثر شيوعًا هو استنشاق الدخان في الحرائق (60٪). كان موقد الفحم المعيب للتدفئة أقل شيوعًا ويعتقد أنه يحدث فقط خلال أشهر الشتاء (20٪). وبالتالي، فإن تقديم أربع حالات تشريح لجثث وجدت متوفاة في سيارات مغلقة في أماكن مفتوحة كان من الجدير بالذكر. وأظهر التشريح والتحاليل أن الوفاة تعود لاستنشاق عرضي مميت لثاني أكسيد الكربون وأظهرت كلتا السيارتين محركات معيبة حيث ارتفع مستوى ثاني أكسيد الكربون داخل الخزانة مما أدى إلى الوفاة أثناء وجود السيارات في أرض مفتوحة وليست في مرآب مغلق. هذه الحالات تستحق الإبلاغ عنها حيث أن نادرًا ما يتم وصفها في علم السموم الشرعي على أنها حدث عرضي بدلاً من تلك التي تحدث من خلال إدخال غاز العادم عمدا إلى داخل سيارة مغلقة من أجل الانتحار.