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# Should Coroners Be Able to Recognize Unintentional Carbon Monoxide-Related Deaths Immediately at the Death Scene?

**REFERENCE:** Risser, D., Bönsch, A., and Schneider, B., "**Should Coroners Be Able to Recognize Unintentional Carbon Monoxide-Related Deaths Immediately at the Death Scene?**" *Journal of Forensic Sciences, JFSCA,* Vol. 40, No. 4, July 1995, pp. 596–598.

**ABSTRACT:** The aim of this retrospective survey of unintentional carbon monoxide-related deaths in Vienna was to determine whether the cherry-pink coloring of livor mortis is a reliable finding for the coroner to suspect a carbon monoxide-related death immediately at the death scene. In addition, we investigated the recognition pattern of unintentional carbon monoxide-related deaths by Viennese coroners between 1984 and 1993. Therefore, we analyzed autopsy reports of postmortems performed at the Viennese Institute of Forensic Medicine between 1984 and 1993. The study involved 182 unintentional carbon monoxide-related deaths: 92 females and 90 males. We found a strong association between the carboxyhemoglobin level and the cherry-pink coloring of livor mortis. In 98.4% of unintentional carbon monoxide-related deaths livor mortis were clearly cherry-pink. During the 10-year study period Viennese coroners recognized only 61% of unintentional carbon monoxide-related deaths immediately at the death scene. The percentage of unrecognized carbon monoxide fatalities with a clear cherry-pink coloring of livor mortis almost doubled from 1984 to 1993. The older the victim, the worse the coroners recognition. In summary, we have shown that coroners should be able to recognize unintentional carbon monoxide-related deaths immediately at the death-scene, because fresh corpses with carboxyhemoglobin levels greater than 31% show a clear cherry-pink coloring of livor mortis. Therefore, coroners should be encouraged to examine naked corpses thoroughly, especially regarding the color of livor mortis. Thus, a carbon monoxide-related death can be recognized immediately and the source of gas release identified as soon as possible protecting people who otherwise would also be at risk of poisoning. A careful investigation at the death-scene and a good degree of suspicion remain the key to early identification of such a hazard.

**KEYWORDS:** pathology and biology, carbon monoxide, death, livor mortis, coroner

Carbon monoxide is a color-, odor- and tasteless gas produced by incomplete combustion of organic materials. Carbon monoxide poisoning occurs frequently in industrialized countries [*1,2*]. Failure to diagnose a carbon monoxide intoxication as soon as possible and to remove the patient and cohabitants immediately from the contaminated environment can lead to serious morbidity and mortality [*3–6*].

In Vienna, the capital of Austria, there are presently 1,642,391 inhabitants who live in 746,760 households [*7*]. About 92% of these households are equipped with gas-fueled devices. Despite the replacement of carbon monoxide-rich coal gas with carbon monoxide-free natural gas in Vienna between 1970 and 1978, people still die of unintentional carbon monoxide poisoning.

Pathological changes attributable to fatal carbon monoxide poisoning include cherry-pink discoloration of the blood and musculature. Furthermore, in textbooks of forensic medicine fresh corpses with carboxyhemoglobin levels greater than 30% are said to show a typically cherry-pink coloring of livor mortis [*8–10*]. Despite this finding, in Vienna many cases of unintentional carbon monoxide-related deaths are not recognized immediately by coroners [*11*]. Since this harmful poisoning is revealed only hours later at the Viennese Institute of Forensic Medicine, cohabitants and neighbors still remain at risk to this life-threatening intoxication until the source of carbon monoxide is eliminated [*12,13*].

This retrospective study aims to determine whether the cherry-pink coloring of livor mortis is a reliable finding for the coroner to suspect a carbon monoxide-related death immediately at the death-scene. In addition, we investigated the recognition pattern of unintentional carbon monoxide-related deaths by Viennese coroners between 1984 and 1993.

## Materials and Methods

Coroners' and post-mortem reports of unintentional carbon monoxide-related deaths, examined at the Institute of Forensic Medicine in Vienna between 1984 and 1993, were analyzed. All deaths for which carbon monoxide was listed as the underlying cause as well as a contributing factor were considered for this retrospective study. In case of fire (flames, burns, explosives) data were excluded from this analysis because the public health issues arising from such deaths are primarily related to preventing house fires [2]. In the case of decomposition, coloring of livor mortis cannot be judged by the coroner. Therefore, these corpses were also excluded. Blood samples for carboxyhemoglobin determination were analyzed using a spectrophotometer (M4 QIII, Carl Zeiss).

Data were summarized as mean ± standard deviation (SD). We considered differences significant at $P < 0.05$. SAS 6.08® (SAS Institute Inc., Cary, NC, USA) was used for numerical analysis.

## Results

### *Study Subjects*

From 1984 to 1993 28,171 corpses were examined at the Institute of Forensic Medicine in Vienna. In 366 cases, unintentional carbon monoxide inhalation was either an underlying cause of death or a contributing factor, 166 deaths were due to fire and therefore

Received for publication 6 Sept. 1994; revised manuscript received 12 Nov. 1994; accepted for publication 12 Nov. 1994.

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were excluded. 18 corpses were decomposed and therefore were also excluded. Thus, the coroners' and postmortem reports of 182 carbon monoxide-related deaths were analyzed. This sample consisted of 92 female victims who were clearly older at time of death than the 90 male victims (68.0 ± 22.3 vs. 50.0 ± 23.3 (SD) years).

### *Carboxyhemoglobin Levels and Color of Livor Mortis*

The older the victim, the lower the carboxyhemoglobin level, which decreased by 0.16% per living year (regression analysis: $P < .0001$), a finding which may be explained by the fact that many elderly people with coronary artery, heart, or lung disease already have a compromised ability to oxygenate. The range and mean of carboxyhemoglobin levels were 18 to 87 and 62 ± 12 (SD) % carboxyhemoglobin, respectively. There was a strong association between the carboxyhemoglobin level and the cherry-pink coloring of livor mortis (Wilcoxon 2-sample test: $P < 0.01$). 3 corpses with 18, 28 and 31% carboxyhemoglobin, respectively, showed no cherry-pink coloring of livor mortis. In 98.4% ($n = 179$) of unintentional carbon monoxide-related deaths livor mortis was clearly cherry-pink.

### *Recognition Pattern of Viennese Coroners*

Three cases showed no cherry-pink coloring of livor mortis and therefore were not considered for calculating the recognition pattern of Viennese coroners. During the 10-year study period coroners recognized only 61% of 179 unintentional carbon monoxide-related deaths immediately at the death scene. The percentage of unrecognized carbon monoxide fatalities with clearly cherry-pink livor mortis almost doubled from 1984 to 1993, whereby this deterioration of the recognition pattern was not statistically significant (Table 1). There was a strong reverse association between the age of the victim and the recognition pattern. The older the victim, the worse the coroners' recognition (Mantel-Haenszel Chi-square: $P < 0.001$) (Table 2).

## Discussion

The cherry-pink coloring of livor mortis is a reliable finding for the coroner to suspect a carbon monoxide-related death immediately at the death-scene. In our sample, only in three cases there was no cherry-pink coloring of livor mortis. However, in 98.4% of unintentional carbon monoxide-related deaths livor mortis was clearly cherry-pink.

TABLE 1—*Unintentional carbon monoxide poisoning with a clear cherry-pink coloring of livor mortis* (n = *179) and recognition pattern of Viennese coroners by year.*

| Year | No. examined | No. unrecognized | % unrecognized | OR[a] | 95% CI[a] |
|---|---|---|---|---|---|
| 1984 | 15 | 4 | 26.7 | 1.0[b] | |
| 1985 | 26 | 9 | 34.6 | 0.69 | 0.17–2.79 |
| 1986 | 27 | 10 | 37.0 | 0.62 | 0.16–2.47 |
| 1987 | 25 | 8 | 32.0 | 0.77 | 0.19–3.20 |
| 1988 | 12 | 5 | 38.5 | 0.58 | 0.12–2.88 |
| 1989 | 19 | 6 | 31.6 | 0.79 | 0.18–3.53 |
| 1990 | 14 | 8 | 57.1 | 0.27 | 0.06–1.30 |
| 1991 | 18 | 8 | 44.4 | 0.46 | 0.10–1.99 |
| 1992 | 11 | 6 | 54.6 | 0.30 | 0.06–1.58 |
| 1993 | 12 | 5 | 41.7 | 0.51 | 0.10–2.57 |
| Total | 179 | 69 | 38.6 | | |

[a]OR, odds ratio; CI, confidence interval.
[b]Referent.

TABLE 2—*Unintentional carbon monoxide-related deaths with a clear cherry-pink coloring of livor mortis* (n = *179) and recognition pattern of Viennese coroners by age.*

| Age | No. examined | No. unrecognized | % unrecognized | OR[a] | 95% CI[a] |
|---|---|---|---|---|---|
| <11 | 2 | 0 | 0.0 | | |
| 11–20 | 13 | 0 | 0.0 | | |
| 21–30 | 21 | 4 | 19.0 | 1.0[b] | |
| 31–40 | 15 | 3 | 20.0 | 0.94 | 0.17–4.99 |
| 41–50 | 16 | 5 | 31.2 | 0.52 | 0.11–2.63 |
| 51–60 | 16 | 5 | 31.2 | 0.52 | 0.11–2.36 |
| 61–70 | 11 | 5 | 45.4 | 0.28 | 0.06–1.41 |
| 71–80 | 39 | 20 | 51.3 | 0.22 | 0.06–0.79 |
| >80 | 46 | 27 | 58.7 | 0.17 | 0.05–0.57 |
| Total | 179 | 69 | 38.6 | | |
| | | Chi-square for trend < 0.001 | | | |

[a]OR, odds ratio; CI, confidence interval.
[b]Referent.

The recognition pattern of unintentional carbon monoxide-related deaths by Viennese coroners between 1984 and 1993 was rather unsatisfactory. Only 61% of deaths with clearly cherry-pink coloring of livor mortis were immediately recognized at the death-scene. Furthermore, the recognition pattern did not change during the 10-year study period. In contrast, the percentage of unrecognized cases doubled from 1984 to 1990, followed by a smooth decrease. This finding is notable, as in Vienna this severe hazard has always been a main issue in lectures, which form part of a compulsory postgraduate course for medical doctors wishing to become coroners. The forensic science module of this postgraduate course, which runs for two semesters, consists of 19 double lessons in which all areas of forensic medicine are covered plus one double lesson with a demonstration post-mortem, and a final exam.

Moreover, all corpses taken into account in this study showed a clear cherry-pink coloring of livor mortis. Thus, in these cases an accurate external examination of the naked body at the death-scene would have been sufficient. Particularly in case of carbon monoxide-related deaths aggressive efforts must be made to eliminate the gas source as soon as possible to protect other people, such as neighbors and cohabitants. Carbon monoxide can also penetrate walls through structural defects [*3,12*]. Thus, still undiagnosed victims could exist who must be immediately identified and promptly treated to reduce the frequency of late, mainly neuropsychiatric, changes [*4,14,15*]. As yet, in Vienna there have been no subsequent intoxications or deaths as a result of a carbon monoxide-related death unrecognized by a coroner at the death scene; however, this possibility can not be ignored as has been seen in other countries [*3,16,17*]. The comprehensive and properly performed investigation of unnatural, sudden, unexpected, and suspicious deaths is necessary to maintain the health, safety, and well-being of society. Adequate death investigation requires the combined efforts and cooperation of law enforcement and other public service agencies, medical professionals, and individuals in the forensic science community. As such, the forensic or death investigator plays a crucial role in the medicolegal investigative process. These front-line investigators, whether they be coroners, medical examiners, medical professionals, or lay individuals, are required to make important decisions which have far reaching consequences on death investigation proceedings and manner of death determinations [*18*].

In summary, we have shown that coroners should be able to recognize unintentional carbon monoxide-related deaths immediately at the death-scene, because fresh corpses with carboxyhemoglobin levels greater than 31%, show a clear cherry-pink coloring of livor mortis. Therefore, coroners should be encouraged to examine naked corpses thoroughly, especially regarding the color of livor mortis. Thus a carbon monoxide-related death can be recognized immediately and the source of gas release identified as soon as possible, protecting people who otherwise would also be at risk of poisoning. It must be reemphasized that not all carbon monoxide-related deaths are immediately obvious, but a careful investigation at the death-scene and a good degree of suspicion remain the key to early identification of such a hazard [*19,20*].

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