CARBON MONOXIDE SUICIDE FROM CAR EXHAUSTS

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Abstract—Study objective: the aim of the study was to analyse the victims and circumstances in carbon monoxide suicides from car exhausts in order to find strategies for mitigation of the suicide risk. Design: necropsy, police and hospital records were scrutinized for 194 victims who committed suicide by carbon monoxide poisoning from car exhausts during a four-year period in Sweden. Setting and participants: the State Institutes of Forensic Medicine in Umeå and Stockholm. Results: a higher incidence (24.2/million population) was seen in the rural region than in the urban region (14.9). Males dominated (88%), most of them middle aged. Most victims committed suicide in a car outdoors. A vacuum cleaner tube connected to the compartment was most commonly used. Severe disease, mostly psychiatric, was seen in 61% of the victims. Drugs were detected in 8% of the victims under psychiatric treatment. In 37%, earlier suicide behaviour was documented. Suicide notes were found in 40%. Blood alcohol was detected in 51% of the victims and other drugs in 7%. Conclusions: environmental changes may reduce the number of carbon monoxide suicides from car exhausts, e.g. introduction of a law requiring catalyst exhaust, of automatic idling stop, and of exhaust pipes incompatible with vacuum cleaner tubes. The importance of accurate treatment of psychiatric patients is stressed.

Key words—carbon monoxide intoxication, car exhausts, suicide, prevention

INTRODUCTION

It is presumed that the availability of opportunities for suicide and conditions which influence the effects of suicidal acts contribute to the number and the outcome of such acts [1, 2]. It is also supposed that measures against mental individual causes are no panacea [3]. Thus, minimizing the environmental prerequisites for suicides should be tried, using experiences from the mitigation of unintentional injuries [4–6]. The preventive effects of gun control [7, 8] and of reducing barbiturate prescriptions [9] favour this opinion.

Furthermore, reduction of the carbon monoxide content of domestic gas in Great Britain caused a 35% decline in the suicide rate [10, 11]. Also, the rate of car exhaust suicides declined in the U.S. following the introduction of car emission control in the mid 1960s [2]. In Great Britain, where emission control is far behind the U.S., the rate of such suicides has increased substantially since 1970 [2, 12]. In Sweden, carbon monoxide poisoning from motor vehicle exhausts is the fourth leading method of committing suicide, accounting for 15% of all male and 3% of all female suicides [13]. Thus, efforts to reduce such suicides should be tried. In this paper, we have made an analysis to find strategies for mitigation of the suicide risk.

MATERIALS AND METHODS

All people who died from carbon monoxide poisoning from car exhausts and who were autopsied at the State Institutes of Forensic Medicine in Umeå or Stockholm during 1984 through 1987, were included in the study. In each case, a complete medico-legal autopsy was performed, including toxicological analyses in most cases. All available police and hospital records were scrutinized.

The district of Stockholm collects medico-legal autopsies from three counties with a population of 1.8 million, most of them urban. The district of Umeå has about 0.9 million inhabitants and collects medico-legal autopsies from the four northern counties, most of them rural, forming the northern half of Sweden.

A carbon monoxide concentration test is included in the annual mandatory motor vehicle check-ups run by The Swedish Motor Vehicle Inspection Company. Information on concentrations of carbon monoxide in exhausts from 30 randomly chosen cars involved in suicides was collected. The effect of catalytic emission control on the carbon monoxide concentration in exhausts was studied for an additional six randomly chosen passenger cars when idling.

RESULTS

The study included 194 victims, 107 (55%) of whom were autopsied in Stockholm and 87 (45%) in Umeå, all fatally poisoned by carbon monoxide from motor vehicle exhaust. The annual incidence was 14.9 suicides/million population in the Stockholm region compared to 24.2 in the Umeå region.
Men dominated the study with 171 cases, constituting 88% of the material. The mean age of the male victims was 43 years ± 15 (mean age ± SD, range 19–84), and of the females 42 years ± 14 (mean age ± SD, range 23–74). No differences between the two regions regarding sex and age were found.

In 119 cases (61%), symptoms and signs of previous disease and illness were documented with a relatively even distribution between the regions. Impairment of mental status was documented in 88 cases, including 39 cases of depression. In 42 cases, the victim was under psychiatric treatment. In an additional 15 victims, alcohol abuse could be verified, in 2 victims alcohol and drug abuse, in 1 narcotic drug addiction, in 4 cancer, and in 9 victims other somatic diseases.

**Suicidal behaviour**

In 33 cases, proof of one or more previous suicidal attempts was found. Suicidal thoughts or suicidal expressions were documented in an additional 25 cases and weariness of life had been expressed by at least an additional 14 victims. Suicidal notes were found in 77 cases (40%). No differences between the two geographical regions were found.

**Social and marital status**

In only 55 cases (28%) was the social status of the victim at the time of the suicide documented. Of these, 24 were divorced or going through a divorce. Major economic problems were documented in 6 cases. The death of a close relative less than two weeks prior to the victim’s death was known in 5 cases, major occupational problems in 3 cases, and other major unspecified social problems in an additional 17 cases. No differences between the regions were found.

**Alcohol and other drugs**

Blood alcohol analyses were performed in 193 cases (99%), yielding 98 victims (51%) with a mean blood alcohol concentration of 1.5 g/kg (SD ± 0.79) (range 0.2–3.9 g/kg). Of the victims tested, 56% of those in Stockholm and 44% of those in Umeå had alcohol detectable. A urine alcohol analysis was performed in 177 cases (91%), and ethanol was found in 84 cases of these (47%) with a mean concentration of 1.9 g/kg (SD ± 0.93) (range 0.3–4.0 g/kg). In 83 cases (47%), ethanol was detected in both blood and urine, of whom the majority (n = 71) had a higher concentration of the urine ethanol.

Drugs were detected in 13 (7%) of 181 cases tested (Table 1). Ten of 13 victims with drugs in the blood were from Stockholm. In only 3 of 39 victims under documented psychiatric treatment and screen tested, were drugs detected, in one case at toxic levels.

**Circumstances**

The place of the incident was known in 183 (94%) cases; most victims were found within the car outdoors (Table 2). In 18% of the Stockholm fatalities, the victims were found in a garage, compared to only 5% of the Umeå fatalities.

In 169 cases (87%) was the position of the victim documented by the police. Most victims (93%) were found inside the car, most of them sitting in the front seat. In all, 5 victims died solely by lying next to the exhaust pipe even though the car was parked outdoors (Table 3).

A tube was used and connected to the exhaust pipe in 140 cases (77%) of the 181 tube cases documented. The dominating type was a tube from a vacuum cleaner (Table 4). Of the 134 cases where it was known how the tube was connected to the compartment of the car, 63 (47%) had inserted the tube through a window, 62 (46%) had inserted it through a boot lid window, whilst only 9 had used a door opening.

Of the 45 cases where the type of sealing was known, insulating tape was most commonly used (25 cases). Others had used textile (9 cases), cord (3 cases), tube-clip (1 case) and steel wire (1 case). In one case, the tube was screwed onto the exhaust pipe and in another, the victim had made a direct connection from the exhaust system to the car compartment. In an additional 4 cases, insulating tape and textile or plastic were combined.

**Time of incident**

The number of victims increased during the second half of the period, including 57% of the victims. The annual proportion of victims from Umeå increased during the study period from 41% to 48%. There was a relatively even distribution by month in both regions with the smallest share in January. A relatively even
Prevention of CO suicide

Table 3. Position and location in 194 suicides by carbon monoxide poisoning from car exhausts

<table>
<thead>
<tr>
<th>Location</th>
<th>Position</th>
<th>n</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Inside the car</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Front seat</td>
<td>Sitting</td>
<td>103</td>
<td>61</td>
</tr>
<tr>
<td></td>
<td>Lying</td>
<td>22</td>
<td>13</td>
</tr>
<tr>
<td>Back seat</td>
<td>Sitting</td>
<td>9</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>Lying</td>
<td>21</td>
<td>12</td>
</tr>
<tr>
<td>Between seats</td>
<td>Lying</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Trunk</td>
<td>Lying</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td><strong>Outside the car</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Behind exhaust pipe</td>
<td>Lying</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>On garage floor</td>
<td>Lying</td>
<td>6</td>
<td>4</td>
</tr>
<tr>
<td><strong>Unknown</strong></td>
<td></td>
<td>25</td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td>194</td>
<td>100</td>
</tr>
</tbody>
</table>

distribution by days was seen, with 44% of the Umeå victims and 36% of the Stockholm victims killed from Fridays through Sundays. In only 26 cases (13%) was the exact time of the suicide known, and of these, 69% occurred between 8 a.m. and 8 p.m.

**Exposure from vehicles involved in carbon monoxide poisoning**

The carbon monoxide content of the exhausts peaked around 2–4% (Fig. 1).

**Effect of catalytic emission control**

As expected, the lowest value of carbon monoxide was found in the catalyst exhausts (Table 5).

**DISCUSSION**

Suicide by carbon monoxide poisoning from a motor vehicle is one of the leading methods to commit suicide in Sweden (Statistics Sweden, 1990) as well as in the United States [14] (p. 64). In our study, the incidence was higher in the rural areas, mostly involving middle-aged victims cf [14] (p. 178). It has been suggested that the houses in rural areas are more likely to have garages, resulting in a higher frequency of carbon monoxide suicides in such regions [14] (p. 74). Using official statistics [15–18], the annual suicide rates in Stockholm was 4.3/100,000 passenger car ownership, compared to 6.7 in Umeå. The correlation between car ownership and suicide by car exhausts, has been viewed in the U.S.A. [19].

A comparison of the four most common suicide methods in Sweden [13], reveals large differences between the sexes. For example, females preferred poisoning by drugs but very seldomly carbon monoxide from motor vehicle exhaust. The latter method was more common among males, particularly in the middle aged [13]. In the United States, males dominated by 3:1 [14] (p. 21) and in our study by almost 9:1. A more frequent use of and access to motor vehicles by males can explain these sex differences. The method also requires more technical skills and a longer period of isolation [20]. In a study of female U.S. college students, Lester [20] showed that they were less likely to choose carbon monoxide poisoning than drug overdoses. The females were more concerned with quickness, painlessness and non-disfigurement than males.

The correlation between suicide and psychiatric illness is well known. A large proportion of the victims in our study had a psychiatric illnesses. Only 3 of 39 victims under documented psychiatric treatment had any drug detected in drug screenings. These data may indicate inadequate medication. About half of the victims were inebriated by alcohol, most often with a larger alcohol concentration in the urine, indicating that suicides by carbon monoxide poisoning are committed when the alcohol is eliminated from the body.

The comparison in the study between catalyst and non-catalyst exhausts indicate, as expected, a lower content of carbon monoxide in catalyst exhaust. Still, the lowest value in the sample is far above the Swedish occupational standard (limit of maximum exposure for 15 min and one day of work) for carbon monoxide [21]. According to our analyses of the carbon monoxide in the car exhausts, it cannot be excluded that suicide cars make a risky selection from the carbon monoxide concentration point of view. Laws, requiring catalyst exhaust could increase the time period required to commit suicide, thus perhaps preventing some deaths (cf [2, 22, 23]).

Most of our victims committed suicide by using a tube connected with the exhaust pipe. Therefore, redesign of exhaust pipes from the round fashion to a more extreme, e.g. a narrow, broad construction should be considered. In this way, exhaust pipes and tubes would be less compatible. As 4 victims out of 10 used a vacuum cleaner tube, a redesign of these is another possibility to consider.

One-fourth of the victims in our study died without any direct connection to the exhaust pipe and five of these died outdoors by placing the mouth next to the exhaust pipe (cf. Ref. [24]). These findings stress the importance of automatic stop related to a maximum time of idling, which should be endorsed also from environmental protection points of view.

If car exhaust suicides are prevented, will then suicidal persons switch to alternative methods?

Detoxification of domestic gas in England and Wales during the 1960s decreased the number of carbon monoxide suicides very strongly. This reduction of domestic gas suicides caused a decline of

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**Table 4. Type of connecting tube used in 194 suicides by carbon monoxide poisoning from car exhausts**

<table>
<thead>
<tr>
<th>Type of tube</th>
<th>n</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vacuum cleaner tube</td>
<td>55</td>
<td>39</td>
</tr>
<tr>
<td>Rubber, not specified</td>
<td>32</td>
<td>23</td>
</tr>
<tr>
<td>Garden hose</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>Bicycle tube</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>Copper tube</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Not specified</td>
<td>44</td>
<td>31</td>
</tr>
<tr>
<td>Tube not used</td>
<td>41</td>
<td></td>
</tr>
<tr>
<td>Unknown</td>
<td>13</td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>194</td>
<td>100</td>
</tr>
</tbody>
</table>

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about 40% in the overall rate of suicide in England and Wales 1963–1975. Possibly, however, some later suicides using car exhausts may be regarded as a small delayed displacement [25, 26].

Detoxification of domestic gas in Scotland and the Netherlands had less effects. A coincident increase in the tendency to commit suicide is an alternative explanation [25, 27].

In the U.S.A., the total suicide rate for domestic gas and car exhausts decreased between 1950 and 1960 substantially for women and slightly for men. Thus, the reduction of carbon monoxide suicides by domestic gas was not compensated for by the increased availability of cars [28]. Car ownership is independent of domestic gas availability. A displacement probably occurred from domestic gas to car exhausts. The above sex differences support this latter explanation.

As a conclusion on carbon monoxide intoxication, experiences from England and Wales thus strongly support the hypothesis of a substantial effect of reducing the availability of means for suicide. The experiences from Scotland, the Netherlands and the U.S.A. suggest that displacement occur. However, rising suicide rates on the whole, and an increasing availability of cars and subsequent increasing opportunities for suicide using exhaust gas, may blur such a conclusion.

Experiences from a few studies on gun control add to the above idea that availability is important: states in the U.S. with stricter handgun control had lower firearm suicide rates and lower overall suicide rates [7, 8, 29]. Suicides by poisoning and hanging/strangulation were not related to firearm availability suggesting that switching does not occur to any great extent. Another interesting experience was that firearm suicide rates increased concomitantly with a decrease of the suicide rate by all other methods. Based on figures for 1959 through 1984, the increase of firearm related suicides was 2.5 per 100,000 per year whereas the decrease of all other suicides was only 0.7 [30]. The increased handgun availability at first stimulated additional suicides, not merely switches between methods; some ambiguity in these results might be explained by poor measurements of gun ownership [29].

Studies of the effects of restricting the availability of drugs favour a substantial effect, as well. Oliver and Hetzel [9], showed a close relationship between the amount of sedatives issued and the number of drug suicides for the years 1961–1970. The incidence of other suicides was not changed during the same period. Marzuk, Leon et al., studying drug overdoses, carbon monoxide poisonings and fall from heights, emphasize availability as the main explanatory variable as to differences in suicide rates among counties in New York State. Displacement might thus depend on the availability and the attractivity of the alternatives to a method which has been prevented [31].

Thus, reduction of availability of means of suicide is convincing and not only a conceivable method to reduce the number of suicides. However, displacement may occur, and if so, it probably compensates partially for the reduced opportunity. Further, as there is a time

<table>
<thead>
<tr>
<th>Distance before test (km)</th>
<th>Injection/carburetter</th>
<th>Catalyst exhaust</th>
<th>Exhaust CO (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2200</td>
<td>Inj</td>
<td>Yes</td>
<td>0.1</td>
</tr>
<tr>
<td>5340</td>
<td>Inj</td>
<td>Yes</td>
<td>0.8</td>
</tr>
<tr>
<td>50,000</td>
<td>Carb</td>
<td>No</td>
<td>2.4</td>
</tr>
<tr>
<td>52,000</td>
<td>Inj</td>
<td>No</td>
<td>0.8</td>
</tr>
<tr>
<td>77,000</td>
<td>Carb</td>
<td>No</td>
<td>1.1</td>
</tr>
<tr>
<td>68,000</td>
<td>Inj</td>
<td>No</td>
<td>3.2</td>
</tr>
</tbody>
</table>
Prevention of CO suicide

delay before displacement is effective, lives will be saved until then.

REFERENCES