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RESEARCH ARTICLE

Analysis of breath carbon monoxide among urban automobile drivers

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ABSTRACT

Background: Air pollution caused by automobiles can pose serious health hazard due to urbanization. Carbon monoxide (CO) is one of the six criteria for air pollution related to urbanization. Urban drivers are occupationally at risk of exposure to CO. **Aims and Objectives:** This study was undertaken to assess the levels of CO in breath among the exposed group of urban automobile drivers and to compare breath CO levels among various group of drivers based on their years of experience or duration of exposure. **Materials and Methods:** A cross-sectional analysis of breath sample for the presence of CO was conducted on automobile drivers (n = 101) using different type of motor vehicles in urban Chennai using breath CO analyzer (Vitalograph 29700). Mean CO levels were compared among groups using ANOVA. Proportion in groups was assessed by χ^2/Fisher's exact test. **Results:** The mean CO of the breath analysis was 2.45 parts per million (ppm) which corresponds to the mean carboxyhemoglobin of 0.68%. Exhaled breath CO was 3–4 ppm in 22.8% of the drivers. 8.9% of the drivers had exhaled breath CO above 9 ppm. Statistically significant difference was observed between duty hours and exhaled breath CO ($P < 0.01$). Drivers who were smokers had a significantly higher breath CO ($P < 0.00$). Drivers who used gas as fuel were having statistically significant higher breath CO ($P < 0.05$). **Conclusions:** CO is potential environmental toxin of air due to vehicle exhaust. Drivers are constantly exposed, which is evident by our report of having higher breath CO with long duty hours. Smoking adds to environmental exposure of CO to automobile drivers.

KEY WORDS: Air Pollution; Breath Analysis; Carbon Monoxide; Drivers; Occupation

INTRODUCTION

Air pollution caused by automobiles can pose serious health hazard. The pollutants from the motor vehicles include particulate matter, hydrocarbons, nitrogen oxides, sulfur dioxide, and carbon monoxide (CO) which can cause severe threat to human health. There has been a tremendous rise in the number of automobile vehicles in urban India in the recent past. Urbanization leads to overwhelming vehicle population and CO is one of the six criteria for air pollution related to urbanization. The estimated annual global emission of CO is enormously high as per recent report by the WHO. CO is derived from various sources due to incomplete combustion of fossil fuel such as automobile exhaust, cigarette smoking, and industrial fumes.[1]

Of all the pollutants listed, CO is quite important because of its colorless and odorless nature. It is also known as the silent killer as death occurs to victims exposed, quietly and quickly. Exposure to CO can cause immediate health problems and can be fatal in high concentrations. Regular exposure to low concentrations of CO as in occupation such as drivers, traffic personnel, and factory workers also produces long-term health effects inducing morbidity and shortening of lifespan. The initial symptoms are similar to food poisoning or flu and can be misdiagnosed. People at risk of occupational exposure often experience such effects.

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Accidental CO poisoning can occur in young drivers and elderly in cold climates.[2] Occult CO poisoning can occur because of high levels of exposure as in case of faulty automobile exhaust system or home heating system.[3] The affinity of CO for hemoglobin is about 240 times that of oxygen. Carboxyhemoglobin (COHb), thus, formed induces anemic hypoxia.[4] CO has high affinity for myoglobin even more than hemoglobin. Binding of CO to myoglobin leads to cardiac depression which worsens the tissue hypoxia. Mild increase in the environmental concentration is, thus, able to induce CO toxicity. CO also binds mitochondrial cytochrome and thereby cellular uptake of oxygen is blocked. The resulting hypoxia induces endothelial cell and platelet release of nitric acid, leading to the formation of peroxynitrate, a free radical. CO toxicity can be acute, as occurs accidently due to accidental exposure in industries which can be fatal. Chronic CO toxicity due to prolonged exposure can also have an adverse effect on health. Manifestations ranging from brief period of unconsciousness to severe neurological damage have been reported. Symptoms range from mild flu-like illness to extreme level of central nervous system (CNS) or neuropsychiatric sequelae depending on the level of toxicity.[5] Delayed neuropsychological sequelae can be observed after 2–40 days.[6] Studies have shown correlation between levels of CO in air with mortality rates and hospital admissions for heart failure.[7,8]

Thus, exposure to CO at varying levels in the workplace produces a range of different effects from headache and lethargy to coma, seizures, and death that can interfere with an individual's working capacity.[9] Diagnosis of CO toxicity is difficult because of vague presentation of diverse symptoms. Simple device like breathalyzer can be used in suspected group of people to overcome this difficulty.[10] These breathalyzer devices were used originally for smoking cessation. As it is non-invasive, rapid, and cheap, it can be widely used to detect CO poisoning in suspected patients.

Due to rapid urbanization, Chennai has the highest vehicle density in India. The population at risk is the people who are periodically exposed to CO in air. Automobile drivers are one among the identified risk group who spend long hours as part of their occupation on roads. It can pose as occupational hazard if not identified at the earliest. Studies pertaining to driver's safety report that CO exposure is associated with workplace accidents.[11] As exposure to CO also affects the CNS, the driving ability can be impaired due to disturbances such as lack of concentration, dizziness, and cognitive performance.

Reports regarding ambient air CO are available in other parts of the globe relating to its effect on the public.[12] Very limited observations are available in this arena, and hence, a need was felt to investigate the presence of CO toxicity among urban automobile drivers using breath analysis. This study was designed in an attempt to analyze the level of CO toxicity among urban automobile drivers.

MATERIALS AND METHODS

This study was a cross-sectional analysis of expiratory breath sample for the presence of CO conducted on automobile drivers using different types of motor vehicles in an urban setup in Chennai. It was carried out during July 2017, after Approval by Institute Ethics Committee. 101 drivers were enrolled as subjects after obtaining informed consent. Data regarding age, duration of exposure, smoking status, history of passive smoking or use of coal fire in the household, place of work, and preexisting medical condition were collected before analyzing for breath CO.

Inclusion Criteria

Automobile drivers in urban area of age group 18–60 years.

Exclusion Criteria

Age more than 60 years, preexisting respiratory disorder, acute upper respiratory tract infections or lower respiratory tract infections, and any other systemic illness.

Heavy traffic zones in Chennai were identified for sample collection of breath analysis of CO from automobile drivers. Four different locations such as bus depots of Chennai, where there was exceedingly high vehicle population were considered for study area. Sampling was done in the evening between 4 pm and 6 pm to maintain uniformity. A single breath sample was collected into a handheld breath CO analyzer (Vitalograph 29700) in accordance with the manufacturer's instructions for use after proper calibration and suitable precautions. The breath analyzer is a non-invasive device which measures breath CO levels in parts per million (ppm) based on the conversion of CO to carbon dioxide (CO_2) over a catalytically active electrode.[13]

Subjects were grouped based on the vehicles they use, smoking status and duration of occupational exposure and symptoms experienced if any due to CO exposure, from the pro forma collected. Data collected were analyzed using SPSS version 23. Quantitative variables such as mean CO (ppm) were compared among groups using ANOVA. $P < 0.05$ was considered as statistically significant. Proportion in groups was assessed by χ^2/Fisher's exact test. Pearson's correlation analysis was used to check for possible correlation between age, experience, and duration of exposure with exhaled breath CO.

RESULTS

The study group comprised urban automobile drivers ($n = 101$), who were enrolled after seeking informed consent. CO was detectable in the breath of all the drivers. The mean CO of the breath analysis was 2.45 ppm which corresponds to the mean COHb of 0.68%. The subjects in our study were categorized into various groups based on their age, duration of experience, smoking status, type of vehicle used, and type of fuel used. The mean age of the study group in years is 39.96, of which 17.8% were <30 and 13.9% were above 40 years of age. Frequency distribution of occupational characteristics such as age, experience, duration of work, and type of vehicle used is depicted in Table 1.

In our study, 62.3% drivers had exhaled breath CO value of <2 ppm. 22.8% of the drivers had about 3–4 ppm of exhaled breath CO. 8.9% had exhaled breath CO above 9 ppm [Table 2]. The mean duration of exposure taken as duty hours among subjects was 12. There was statistically significant difference in proportion between the duty hours and exhaled breath CO ($P < 0.01$) by Fisher's exact test. Similarly, statistically significant difference in proportion was also observed with smoking status and breath CO ($P < 0.00$) [Table 3].

We compared the different fuel used by the vehicles, namely, petrol, diesel, and gas with breath CO using ANOVA.

The difference was statistically significant ($P < 0.05$). Vehicle users with gas had a higher breath CO when compared to vehicle users with petrol and vehicle users with diesel.

Table 1: Characteristics of automobile drivers based on their occupation

Characteristics	Percentage
Age (years)	
<30	17.8
30–40	32.7
40–50	35.6
Above 50	13.9
Experience (years)	
<5	91.1
5–10	3.9
10–15	2.0
Above 15	3.0
Duration of work (h)	
<10	49.5
10–15	18.8
Above 15	31.7
Automobile	
Auto-rickshaw-D*	2.0
Auto-rickshaw-G#	20.8
Auto-rickshaw-P**	7.9
Bus Non-AC-D	53.4
Bus AC-D	2.0
Cab-D	4.0
Share Taxi-D	6.9
Traveller's Van Non-AC-D	1.0
Traveller's Van AC-D	1.0
Van-D	1.0

*D: Diesel, **P: Petrol, #G: Gas

We also observed higher breath CO among auto-rickshaw drivers when compared to bus drivers which were highly statistically significant ($P = 0.00$), [Table 4]. Mean duration of experience in years of our study population is 14.68. Duration of experience was significantly correlated with breath CO ($P = 0.26$).

DISCUSSION

In this study, we analyzed the breath CO among automobile drivers who are constantly exposed to vehicle exhaust. The mean CO in ppm (2.45) and mean COHb equivalent is 0.68% which is within the accepted limits and in agreement with report by other studies.[14,15] Urbanization and growth of vehicle industry makes Chennai city a prominent site for air pollution. The ambient air in the heavy traffic zones of Chennai is a determinant of breath CO of exposed individuals in our study. Fuel used by drivers in our study group was compared which showed significant difference among fuel such as petrol, diesel, or gas. We obtained significantly higher mean breath CO (6.80 ± 8.12) with gas as fuel. Similarly, the type of vehicle comparison showed significantly higher breath CO (6.34 ± 7.9) in drivers of auto rickshaw. Experience in years was significantly correlated with breath CO in our

Table 2: Percentage distribution of CO (ppm) among urban automobile drivers

CO (ppm)	Percentage
<2	62.3
3–4	22.8
4–5	1.0
5–6	1.0
6–7	1.0
7–8	1.0
8–9	2.0
Above 9	8.9

CO: Carbon monoxide, ppm: Parts per million

Table 3: Smoking status of automobile drivers and breath CO

Smoking status	ppm*	*P* value
Smoker (*n*=27)	8.96±1.57	0.000
Non-smoker (*n*=74)	2.14±0.12	

*Mean±SEM. SEM: Standard error of the mean, CO: Carbon monoxide, ppm: Parts per million

Table 4: Comparison of breath CO between drivers of bus and auto-rickshaw

Vehicle type	ppm*	*P* value
Bus (*n*=59)	3.19±0.48	0.000
Auto-rickshaw (*n*=29)	6.34±1.46	

*Mean±SEM. SEM: Standard error of the mean, CO: Carbon monoxide, ppm: Parts per million study. Smokers (27%) had a significantly high concentration of breath CO than the non-smokers.

Data from air quality index support the fact that air quality index of Chennai is 59 with the prominent pollutant being CO. Other determinants of CO exposure are the duration of exposure as determined by occupation and rate of alveolar ventilation. Hence, drivers from urban regions are highly susceptible to exceed the exposure limit of CO. Our study group consisted of drivers with varied experience and duration of exposure. The mean duration of duty hours of our study group is 12. About 8.9% of the study group had above 9 ppm of breath CO. Smokers had a significantly high concentration of breath CO than the non-smokers. Tobacco smoking is the prominent cause of rise in breath CO when compared to other sources such as vehicle exhaust, wood burners, open fireplaces, and generators.[16] These groups of drivers who smoke are at increased risk of CO toxicity due to added environmental, occupational exposure. Smoking itself will increase the cardiovascular morbidity predisposing to toxic effects of CO even at low concentration.

Mean breath CO of drivers who used gas as fuel was significantly higher. This can be explained by the fact that there was proportionately more number of smokers in the vehicle group that used gas as fuel. Furthermore, gas as a fuel produces considerable high ambient CO.[17] Auto-rickshaw drivers exhibited significantly higher breath CO due to the long waiting period amidst the heavy traffic in our study. Experience in years was significantly correlated with breath CO in our study. The chronic period of exposure could probably be explained as a cause. Similar study reports prolonged exposure to low levels of CO in ambient air that can induce significant morbidity.[18] The half-life of inhaled CO ranges from 2 to 6 h which can vary due to other determinants like respiratory rate.[19] Presentations of symptoms in chronic exposure can mimic ill health.

Reports related to ambient CO in vehicle are clue to the environmental factors rather than individual exposure as analyzed in our study.[20] Most of the studies have observation with COHb estimation in suspected group. We have included a simple non-invasive method of breath analysis of CO which is rapid and reliable. Moreover, COHb often does not correlate with symptoms at presentation according to previous studies.[21] Clinical evaluation with correlation of symptoms and occupational history can prevent misdiagnosis and early treatment.

As our study was limited to cross-sectional analyses, follow-up of drivers at risk will facilitate researchers to assess the actual limit of toxicity produced. Sample size and brief period of study was the study limitation. We included only healthy volunteers ($n = 101$) without any comorbid conditions which could be the limitations of our study. Since the symptoms are vague and non-specific and also as improvement occurs after moving away from the source, exposed individuals may underreport the conditions which can be detrimental to health-seeking behavior. Unintentional poisoning, thus, is possible and due to its property, CO can be a silent killer.

CONCLUSIONS

The breath analysis of CO enabled us to understand the magnitude of pollution at certain areas of Chennai. Although the observed breath CO of automobile drivers was not exceeding the toxic limits, still the automobile drivers are prone for chronic toxicity.

Breath analysis of CO among the study group helped us to draw association between breath CO and the various parameters such as type of vehicle, smoking status, fuel used, and experience. Further, research is required to include other vehicle and population-based survey is required to study the impact of CO toxicity on public health and implications for setting occupational exposure limits.

Monitoring and strict periodic surveillance of vehicles related to emission standards should be followed to control the CO in air to reduce the source from vehicle exhaust. Drivers should be advised to maintain the vehicle standards and updated regarding the symptoms of CO toxicity to overcome this situation. Simple devices to monitor ambient air CO inside the vehicle can also be advocated. Health education on effects of smoking and CO toxicity in addition to the environmental pollution should be emphasized to occupationally exposed, automobile drivers.

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