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A Comparison of Occupational CO Levels, HbCO, and Lung Functions Between Grill and Non-grill Street Vendors

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ABSTRACT

Background: There is a surge increase in grills-fast food outlet in the urban areas that plays an essential role in producing air pollution. Chronic accumulation of carbon monoxide might affect the airway and destroy alveolus as well as correlated with the disturbance of lung function. **Objective:** The purpose of this study is to compare the occupational CO levels, HbCO, and lung functions between grill and non-grill street vendors. **Methods:** This was an observational analytic study with a case-control design. The subjects were grill street vendors and non-grill street vendors in Medan city who fulfilled several inclusion criteria. The questionnaire was used to determine some characteristics, while smokerlyzer, and ELISA for expiration CO level and blood CO level, spirometer was used to determining lung function. Logistic regression was performed with p-value < 0.05 considered to be significant using SPSS ver 24.0. **Results:** A total of 50 subjects enrolled into this study with the majority of subjects in the case group were in red (40%) zone in CO exhaled test with the results in pulmonary function test, predominantly restrictive (56%) and mixed-type (40%) with the mean value of HbCO was 486.16 (ng/mL). Meanwhile, the majority of subjects were green zone with mixed type of lung function disturbance in the control group with 540.15(ng/mL) as HBCO mean value. Grilled street vendors have a higher level of exhaled CO level (p- value: 0.03) without significant difference in HbCO and lung functions (p-value > 0.05). Age, smoking status, HbCO, and lung function did not significantly affect the CO level (p-value: 0.05). **Conclusion**: There was a significant difference in exhaled CO level between grill-and non-grill street vendors without significant difference in HbCO and lung functions.

Keywords: Occupational CO Levels, HbCO, Lung Functions.

1. BACKGROUND

The increasing number of grills-fast food outlets in the urban areas plays an important factor as the air-pollutant source and impact in public health (1). Higher levels of Carbon-dioxide (CO2), carbon-monoxide (CO), sulfur dioxide (SO2), Nitrogen dioxide (NO2), and benzene (2) were produced by the combustion of fossil fuel including charcoal and burning wood in grilling food served (2–4). This air pollutant has related to few diseases related to airway and parenchymal disease, including COPD and asthma (5, 6).

The increasing number of the incidence in Chronic Obstructive of Pulmonary Disease (COPD) in the never smoker population revealed besides age, race, and genetic predisposition, wood smoke, and charcoal exposure must be considered to the development of airway disease (7). Restaurant workers are a population who has a higher risk of developing lung disease results from burning fuel and fumes from cooking. According to a recent study, they have a higher risk of developing respiratory symptoms and exacerbation of asthma and chronic bronchitis (8). CO contributes to this phenomenon. The increasing level of CO has associated with the degree of airway obstruction in adults and children according to several studies (5, 9).

CO, as one of the toxic pollutants, resulted from the grilling process that might affect the airway, lung parenchymal destruction, and systemic manifestation. CO is a colorless and odorless gas that diffuses across the alveolar-capillary membrane and binds with hemoglobin in the pulmonary capillary blood, thereby forming carboxyhemoglobin (COHb) (10,11). CO has 210 folds higher affinity to bind Hb than oxygen. High COHb complex in blood circulation could affect human body function, for example, headache, blurred vision, nausea, lassitude, and vertigo [4,5]. Besides, CO poisoning also resulted from hypoxia state causedby oxygen binding blocked with mitochondrial cytochrome aa3 (12). In this study, COHb quantitated measured with ELISA method and read by spectrophotometric methods, in line with recent articles and research journals (13). Exhaled CO levels represent oxidative stress and early airway inflammation. A higher level of expiration CO levels may predict the early destruction of airway and lung parenchymal before the clinical manifestations occurred (5).

2. OBJECTIVE

This study aims to compare the occupational CO levels, HbCO, and lung functions between grill and non-grill street vendors.

3. MATERIAL AND METHODS

Study Design and Participants

We conducted a case-control study on July-December 2019 in Medan. This study involved a total of 50 participants, divided into 25 participants as case and the other 25 participants as control. Ethics approval was accepted by the Ethics committee of Faculty of Medicine, Universitas Sumatera Utara, Medan, Indonesia. All participants have approved and signed the informed consent before enrolled in this study.

This study is a consecutive sampling where participants who met inclusion criteria and had no exclusion criteria enrolled in this study to meet the minimum samples (22 participants for each group).

The inclusion criteria in the case group were 20-60 years old, who has worked as grill street vendors for a minimum of two years, and there was no history of biomass exposure. The inclusion criteria in the control group were 20-60 years old, who has worked as non-grill street vendors for a minimum of two years, and there was no history of biomass exposure.

The exclusion criteria were the participants who refused to sign the informed consent and had other respiratory diseases, including tuberculosis, malignancy, asthma, COPD, and non-respiratory disease that could affect the CO levels, including coronary artery disease, hemolytic anemia, and hypersplenism (14). A total of 50 participants involved in this study, with 25 participants belonged to the case group and the other 25 participants in the control group.

Questionnaires

Questionnaires used to screen potential participants. All of them would fill the questionnaire regarding the name, age, address (near some factories or not), smoking status, the job history and the duration, history of disease and medication, the history of biomass exposure including regular burning garbage, mosquito repellent, burning wood, animal dung). All the completed questionnaires then collect to the research assistant to be analyzed.

Spirometry

Lung functions were measured by spirometry. We used the Vitalograph Alpha™ model 2000 for the specification of the spirometer and calibrated it daily. It was performed after the participants finished their work, around 7-8 p.m, by the trained researchers after three acceptable and repeatable maneuvers. All of those tests interpreted by the pulmonologist, and the best value was selected to analyze. In this study, we measured FEV1 and FVC to rule out if there was an obstructive, restrictive, or mixed type of pulmonary disease. Obstructive disease was diagnosed when FEV1/FVC < 70% (15) and restrictive disease if FVC <80% (16). Mixed disease if there was an obstructive and restrictive disease.

Exhaled CO Levels

Smokerlyzer with BX615 specification for gas detector was performed to measure the exhaled CO levels. Patients asked to maximal inhales then exhale into the mouthpiece of *smokerlyzer*. The CO levels divided into two groups according to the total subjects' median value.

HbCO

5 mL of the venous blood sample was taken and collected into a blood tube containing EDTA as an anticoagulant. HbCO then analyzed within 24 hours using direct spectrophotometric measurements in specific blood gas analyzers (17). HbCO levels grouped into two categories based on the median value.

Data analysis

All the collected data then entered and analyzed using Statistical Package for the Social Sciences (SPSS) ver 24.0. We compared the exhaled CO levels, HbCO, FEV1, and FVC between grill and non-grill street vendors using Logistic Regression. P-value < 0.05 considered to be significant.

4. RESULTS

Baseline characteristics

The characteristic of all participants was depicted in Table 1. Both groups had almost the same age group (20-29 years old). The majority of both had > 4 years of

Variable	Category	Grill street vendors		Non-grill street vendors	
		Frequency	Percentage (%)	Frequency	Percentage (%)
Age	20 – 29	18	72	13	52
	30 – 39	4	16	8	32
	40 – 59	3	12	4	16
Working Experience	2 years	9	36	8	32
	3 – 4 years	6	24	7	28
	>4 years	10	40	10	40
Exhaled CO level	Green	8	32	10	40
	Orange	7	28	10	40
	Red	10	40	5	20
Pulmonary Function	Normal	1	4	4	16
	Obstructive	0	0	1	4
	Restrictive	14	56	5	20
	Mixed-type	10	40	15	60
Total	25	100	25	100	

Table 1. Baseline Characteristics of participants

Variables	Participants		p-value	Confidence Interval	
	Grill street vendors	Non-grill street vendors		Upper	Lower
FEV1 (%)	74.76 ± 9.77	74.80 ± 13.99	0.99	-6.89	6.81
FVC (%)	66.84 ± 8.90	68.16 ± 11.82	0.64	-7.27	4.63
Exhaled CO levels (ppm)	10.56 ± 7.16	6.88 ± 4.00	0.03*	0.38	6.97
HbCO (ng/ml)	486.16 ± 290.36	540.14 ± 187.89	0.439	-193.06	85.86

Table 2. Comparisons between the grill and non-grill street vendors. Independent T-Test, *p-value considered significant

working experience (40%). In grill street vendors, most participants were in the red zone of exhaled CO levels (40%). This is different from non-grilled street vendors who were in the green and orange zone (40%). According to pulmonary functions, both groups reported the mixed-type abnormality (40%; 60%) followed by restrictive type (56%; 20%).

There were significant differences between occupational exhaled CO levels among both groups. Through descriptive analysis, higher levels of CO were demonstrated in grilled street vendors with reduced function of the lung, which then categorized into obstructive and restrictive. Although, after analyzed using the Spearman Correlation test, we found no significant correlations between CO and FEV1 (p-value: 0.068) or between CO and FVC (p-value: 0.251) in grilled street vendors. We also correlate the CO levels and the age of the participants, but we cannot find any significant correlation (p-value: 0.463). Smoking, as one of the confounding factors in the increasing exhaled CO levels, did not affect the results. In this study, there was no significant correlation between CO levels and Brinkmann index (p-value: 0.144).

5. DISCUSSION

A comparison of occupational exposure among street vendors has been demonstrated in this study through the representation of lung functions, exhaled CO levels, and HbCO that stratified into grill and non-grill street vendors in one location. The study location is mostly known as the reservoir of street vendors across the city without adequate protective equipment, such as face mask and coverings. Several baseline characteristics of participants have also been encouraged into the descriptive analysis between each group. Age has a similar distribution among street vendors, while the duration of working experience and co- morbid was demonstrated insignificantly different. As a result, the study profoundly proved that higher CO levels had been linked to the occupational pollution for the grilled street. Also, it is worth noting that lung function was also affected by a high prevalence of mixed type in almost half of the participants in the study. However, it was not significantly differences between groups.

Still, few case series discovered that acute exposure in a high level of CO could lead to serious intoxication. Serial cases of barbequing caused CO intoxications have been reported in a few studies, where the increasing incidence mostly presents in winter. From those reports, evidence of CO intoxication in indoor barbeque activity was higher and varied from mild symptoms including fatigue, headache, dizziness, nausea, vomitus to more severe cases like syncope and permanent neurological impairment. This presents the correlation of charcoal combustion from grilling cooked and the severe intoxication caused by CO (18). According to WHO, more than six ppm of CO level is potentially toxic over a longer period to human health (19). Nevertheless, Dikme et al. reported a 22-years old-man with mild CO intoxication after barbequing outdoor. From the report, the HbCO was 24%, where it was sufficient for causing neurological manifestation (20).

Few studies also reported the intoxication of CO levels in a larger scale. Madani et al. reported 100 males worked as charcoal-meat grilling exposed to significant levels of carbon monoxide with a higher-level from WHO recommended for CO levels (21). The production of organic and inorganic compounds produced by incomplete combustion of biomass produced a high amount of carbon monoxide. Charcoal and firewood, the most fuel used in commercial grills fast-food, contribute to the amount of carbon-monoxide and carbon-dioxide levels (22). Another study showed the indirect effect of CO on blood parameters. Purbayanti et study exhibited there was an impairment of blood parameters including erythrocytes, RBC count, and hematocrit levels in 90 workers of grilled fish compare with the non-grilled fish (23). This produced from tissue hypoxia which correlates with the increasing amount of air pollution, including CO levels in some studies.

Exhaled CO levels represent the systemic elimination of CO from the respiratory system, mainly through alveolus (24). The higher level of CO relate to few conditions, included external and internal source. External sources produced by outdoor and indoor air pollution with the highest level is from motorized vehicle emission followed by industrial and cooking emission, while the internal source resulted by heme catabolism manifested from several systemic diseases including coronary artery disease, sepsis, and hemolytic anemia (18). For its characteristics as odorless, colorless, and tasteless gas, persistent accumulation of CO levels in the airway and alveolus was commonly underdiagnosed (25).

In line with that study, we revealed a higher level of exhaled CO in grilled street vendors group compare with non-grilled. Although there was no significant difference in lung functions, it depicted the early destruction of the airway and alveolus. Recent studies showed that exhaled CO levels reflect the product of heme-oxygenase in the respiratory epithelium as the consequences of oxidative stress and initial inflammation in the airway (5,24). So, before the clinical manifestations occurred, the exhaled CO level may be higher than usual. Nevertheless, the high level of exhaled CO mostly associated with the smoking status. The limitation of this study is we cannot equalize the smoking status of the participants in order to exclude the confounding factor affect the exhaled CO level.

After inhaled, CO will diffuse into systemic vascular and bind to hemoglobin, forming HbCO. Its affinity to hemoglobin is much higher than oxygen (26). It resulted in hypoxia state and activated the systemic inflammation, which further induced the heme-oxygenase and led to increasing the intrinsic CO (27). Along with the statements in the previous paragraph, which explains the several factors affecting the CO levels, this study showed the non-grilled street-vendor group had a higher HbCO compare with the grilled street vendors group. There might be other factors affecting this high level of HbCO. Smoking, since the 1970s had been considered to increase the blood carboxyhemoglobin up to 2.2% after inhaled for 20 minutes in 1 cigarette (28). Another study also revealed that smoking more than 20 cigarettes each day may excess HbCO ten fold compare with the non-smoker (29). Hemolytic anemia may induce the increase of carboxyhemoglobin up to 9.7% according to Chan and Ngai study (30), so routine blood examination maybe considered to exclude confounding factors affect this study.

CO and other toxic gasses from burning wood and charcoal in grilled food have been considered to reduce lung functions in various mechanisms (31–33). Carbon monoxide affects the nucleus and alters several cellular signaling. Further, mitochondria, the center of energy metabolism is affected by CO. CO will induce the proinflammatory and proapoptotic cytokines, productions of reactive oxygen species lead to the inflammatory process and apoptotic of the respiratory epithelium (34). If the inflammatory process occurscontinuously, there will be the destruction of the bronchial wall and alveolus. In the severe case of intoxications, a study revealed the vascular congestion and hemorrhage around the alveolus, manifest as acute pulmonary edema (35). For the chronic poisoning, the longer duration of inflammation results in the breakdown of elastic fiber, and the muscular layer of the airway to fibrotic change (31).

The amalgamation of inhaled toxic gases would produce irreversible airway obstruction that impairs breathing, thus evidentlyshowed in spirometry examination. In recent days, there was no study concluding the duration of biomass exposure and airway obstruction.

Regarding those cases above, chronic carbon-monoxide intoxication could be classified as an occupational disease. There must be incorporated teamwork between the owners of the grilled-street vendors and the government to overcome this issue. A simple alternative method is using a simple mask for filtering the number of air pollutants inhaled. Further, the emission control devices can be used to control the level of air pollution resulted from charcoal-grilling street vendors (36), so it can reduce the impact on public health.

The limitation of this study is we could not examine the genetic alteration and the amount of air pollution from the environment, which can influence the level of CO levels and lung functions of the participants. Further studies involved the larger scale of participants are needed the minimize the internal factors that could result in interference of the study results.

6. CONCLUSION

From this observational study, we found that regular practice of grilling for one year significantly affects the exhaled CO levels although it did not significantly predispose the disturbance of lung functions and HbCO.

- **Patients Consent Statement**: The first author confirms that patients consent to enroll in the study was obtained. The authors certify that they have obtained all appropriate patient consent.
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