Noninvasive Measurement of Carbon Monoxide Levels in ED Patients with Headache

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ABSTRACT

Objectives: Carbon Monoxide (CO), the third most common cause of acute poisoning death, is easily overlooked in the emergency department (ED). Nonspecific complaints such as headache, weakness, or malaise may easily result in misdiagnosis. The objectives of this study are to determine the frequency of CO poisoning in patients presenting to the ED complaining of headaches and to determine the feasibility of using noninvasive CO analyzers as a screening tool.

Methods: This prospective controlled study examined, during the winter months, adult patients presenting with a complaint of atraumatic, afebrile headaches. All subjects submitted a sample for a CO breath analyzer. Participants with elevated carboxyhemoglobin (COHb) levels (nonsmokers >2%, smokers >5%) underwent venous COHb testing. Control patients, without headaches, presenting to the ED were similarly studied.

Results: We enrolled 170 subjects and 98 controls. Of the 170 subjects, 12 (7.1%) had elevated COHb levels confirmed by venous COHb levels. Of the 98 controls, 1 (1.0%) had an elevated COHb level ($p < 0.05$). There were no differences in demographic factors between the two groups ($p > 0.16$).

Conclusions: Noninvasive measurement of CO levels in ED patients with headaches is rapid and specific. During winter months, elevated CO levels are present in over 7% of ED patients with headaches.

INTRODUCTION

Particularly in its milder forms, carbon monoxide (CO), the third most frequent cause of acute poisoning death, is easily unnoticed in the ED setting. Patients often present to the ED with nonspecific complaints of headache, weakness, or malaise and may be easily misdiagnosed with migraine or viral syndrome. When misdiagnosed, these patients may return to a hazardous environment and continue to be exposed to CO. Since CO is generated by the incomplete combustion of any organic substance, exposure is potentially very common: especially in a modern society that uses hydrocarbon powered vehicles and machinery. Exposure to CO is more likely during the colder months, but may

occur at any time throughout the year and should be kept in the differential of ED patients with headaches [1].

Traditionally, the diagnosis of CO poisoning required a draw of arterial or venous levels; in recent years however, readily available noninvasive CO breath analyzers have been a rapid and reliable method of determining carboxyhemoglobin (COHb) levels [2]. Although relatively inexpensive, breath analyzers have never been evaluated as a screening tool for adult ED patients with headaches.

The purpose of this clinical study was twofold:

1. To determine the frequency of CO poisoning in patients presenting to the ED with the complaint

Keywords: carbon monoxide, breath analyzer, headache

Notes: This data has previously been presented at American College of Emergency Physician's Scientific Assembly in October 2004. There was no outside funding of any kind used for this study.

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of headaches with or without other associated symptoms.

2. To determine the feasibility of using noninvasive CO analyzers as a screening tool to determine which patients should receive formal CO testing.

MATERIALS AND METHODS

This was a prospective controlled clinical study utilizing a convenience sample of adult patients presenting to the EDs in two active community teaching hospitals in Northeast Pennsylvania; the study took place from October 2003 to April 2004 and from October 2004 to April 2005. Patients (18 years and older) who presented with the complaint of atraumatic, afebrile headaches with or without associated symptoms were eligible to participate in this study. Enrollment of subjects and controls spanned all hours and days of the week. A chief complaint of headache was not required; however, to enroll a patient in the study, headache had to be a component in the constellation of symptoms. We excluded patients who were hemodynamically unstable, could not hold their breath for 20 seconds, or those with known CO exposure. In addition, we similarly recruited control subjects (who presented to the ED with complaints of minor trauma but no headache) and matched for age, gender, and smoking status over the same timeframe. Control subjects were used to determine the baseline CO levels in our patient population. Consent was obtained, and all subjects and controls were asked to fill out a brief questionnaire prior to the breath analysis. The questionnaire addressed smoking status (active/passive), time since last cigarette, age, type of vehicle and home heating source. Study subjects were asked to hold their breath for 20 seconds and then breathe into the Micro CO Breath Analyzer (Micro Medical Limited, Rochester, Kent, UK) [3]. The CO levels were displayed in units of ppm and %COHb. A microprocessor detects peak expired concentrations of alveolar gas. This is then converted to %COHb using the mathematical relationship described by Jarvis et al. for concentrations below 90 ppm [4]. Individuals with elevated breath COHb levels (nonsmokers >2%, smokers >5%), according to the usual standards for our hospital laboratory, underwent confirmatory blood serum level analysis. In patients with a normal breath CO level, no further CO testing was done. Therapeutic interventions in patients with elevated levels were left to the discretion of the treating physician. The Internal Review Boards of both hospitals approved the study. All comparisons were by Chi square with alpha set at 0.05.

RESULTS

We enrolled a total of 170 ED patients who met inclusion criteria of atraumatic, afebrile headaches and 98 controls matched for age, sex, and smoking status. Overall, 12 of 170 (7.1%) of our study group had elevated breath CO levels compared to only 1 of 98 (1.0%) of the control group ($p = 0.025$). Of the 12 positive study subjects, 8 were smokers and 4 were non-smokers; 9 had

blood serum levels drawn, all of which confirmed the elevated levels provided by the noninvasive analyzer (Table 1). There were no statistically significant differences between the matched controls and study groups with regard to age, gender, smoking status, secondhand smoke exposure, or home heating source ($P > 0.17$) (Table 2).

DISCUSSION

Although breath analysis for CO measurement has been available for many years, its use has been largely limited to occupational, industrial, and public health settings; more recently it has been employed for smoking cessation programs. To our knowledge, this is only the third study to utilize breath analysis of CO as a diagnostic device in the ED setting and the first study to use breath analysis as a screening tool in adults with headaches. The actual incidence of occult CO intoxication in ED populations has varied from 2% to 23.6%. Some of this variance is certainly related to the fact that the very definition of an elevated CO level continues to be debated.

In one study that only investigated venous COHb, a 7% incidence of unsuspected CO poisoning was found on all patients presenting to the ED with headaches, including those associated with fever and trauma [5]. A different group studied the incidence of CO poisoning in patients presenting with nonspecific flu-like symptoms and found a 23.6% incidence of venous COHb levels greater than 10%. That study also demonstrated elevated levels more frequently in patients using wood heat than in those using other sources of heat [6]. These studies indicate that CO poisonings, in its milder forms, may be difficult to identify from history and physical alone. Therefore, a high suspicion and ancillary testing are needed to make the diagnosis. Our results indicate that a positive value on breath analysis obtained

TABLE 1. Subjects with Elevated CO Levels

Age	Gender	Breath (%COHb)	Breath (ppm)	Blood (%CO)	Smoker
35	F	2.40	15	Not Drawn	N
21	M	2.72	16	Not Drawn	N
45	F	3.46	20	5.4	N
31	F	3.60	21	5.4	N
43	F	5.76	32	5.6	Y
52	M	5.92	32	9.3	Y
52	M	6.08	33	5.5	Y
33	M	6.24	34	7.9	Y
29	F	6.32	34	Refused	Y
40	F	6.88	37	8.0	Y
39	F	11.36	60	9.3	Y
31	F	11.44	60	9.1	Y

TABLE 2. Significance of Age, Gender, Smoking, Heating Source, and Vehicle

		Subjects	Percent	Controls	Percent	P value
Age (mean)		39.2	-	38.7	-	0.612
Gender						0.527
	Male	59	34.7	38	36.5	
	Female	110	64.7	60	61.2	
	Not answered	1	0.6	0	0	
Smoking Status						0.742
	Smoker	57	33.5	36	36.7	
	Nonsmoker	112	65.9	62	63.3	
	Not answered	1	0.6	0	0	
Smoker		57	33.5	36	36.7	0.355
Number of Packs	<1/2 ppd	29	50.9	17	47.2	
	1/2–1 ppd	21	36.8	17	47.2	
	1–2 ppd	7	12.3	2	5.6	
Time since last cigarette						0.179
	<1 hr	5	8.8	8	22.2	
	1–2 hrs	13	22.8	11	30.6	
	2–3 hrs	15	26.3	5	13.9	
	>3 hrs	22	38.6	12	33.3	
	Not answered	2	3.5	0	0	
Nonsmoker		112	65.9	62	63.3	
Nonsmoker w/ secondhand smoke exposure		35	31.3	24	38.7	0.281
Time since last smoke exposure						0.488
	<1 hr	5	6.9	0	0	
	1–2 hrs	11	19.6	5	20.8	
	2–3 hrs	6	10.7	2	8.3	
	>3 hrs	34	60.7	16	66.7	
	Not answered	0	0	1	4.2	
Heat Source						0.260
	Oil	60	35.3	31	31.6	
	Electric	44	25.9	38	38.8	
	Gas	57	33.5	26	26.5	
	Coal	3	1.8	1	1.0	
	Wood Stove	1	0.6	2	2.0	
	Gas Fireplace	1	0.6	0	0	
	Not answered	4	2.3	0	0	

from patients presenting with headaches, even as a secondary complaint, does in fact represent an elevated COHb level, as usually defined and confirmed by traditional testing.

Other studies have been performed using CO breath analyzers but all have utilized different criteria for enrollment. In 1998,

a CO breath analyzer was used as a screening tool in a convenience sample of all children, regardless of complaint, presenting to the ED. Two percent of that population had elevated COHb levels. In those with elevated breath levels, confirmatory co-oximetric analysis of capillary blood was performed and found to

correlate with COHb levels from the breath analyzer [7]. The analyzer has also been used by Turnbull to screen a convenience sample of all adults, regardless of complaint, presenting to an ED. He concluded that routine screening of ED patients for unsuspected CO exposure is not practical [8]. Recently, a study of 382 subjects who underwent breath analysis for CO and completed a questionnaire about possible sources of CO exposure showed breath analysis results correlated well with CO exposure. It did not specifically evaluate patients with symptoms of CO poisoning nor did it correlate their elevated levels with serum COHb levels [9].

Our finding of a 7.1% incidence of elevated COHb levels in patients with headaches, patients not suspected of having CO poisoning, only reinforces the need for physicians to consider CO poisoning in the differential. Given the relatively low equipment costs (MicroCO Breath Analyzer \$995, disposable cardboard breathing tube inserts \$10/100 tubes) and ease of use, triage nurses could perform CO breath analysis on patients who present to the ED with the chief complaint of atraumatic, afebrile headaches. It should be noted that the main action taken in the treatment of our subjects was informing them of the need to have their home, work, and vehicle environments evaluated for sources of CO.

LIMITATIONS

Our study has limitations that should be noted. Most importantly we did not perform confirmatory venous COHb levels on those study subjects in whom CO breath analysis detected normal levels. Therefore, it is not possible to calculate the sensitivity or negative predictive value of the breath analyzer. However, the sensitivity of the device is reported by the manufacturer as 1 ppm or 0.0001% COHb [3]. Not all subjects had confirmatory venous testing. One subject refused to have their blood drawn, while the treating physician in two other cases failed to follow study protocol and obtain blood samples for analysis. Some gases (ethyl alcohol, hydrogen sulfide and sulfur dioxide) are noted to interfere with the breath analyzer; but in all cases, 100 ppm of the gas are required to produce a 1 ppm elevation on the MicroCO meter [3]. A history of alcohol intake was not obtained from our subjects or controls, but none of the subjects appeared clinically intoxicated. It is unlikely that small amounts of alcohol would have made a significant difference.

This study was not designed for follow up and the sources of CO exposure were not identified in the majority of subjects. However, the sources of exposure were known in two cases. One individual was found to have a faulty exhaust system in her new car and another individual's elevated level was caused by a poorly ventilated fireplace. We do not have knowledge of which individuals owned CO detectors, and we do not have knowledge of CO detector regulations in our area.

CONCLUSIONS

Noninvasive measurement of CO levels in ED patients with headaches is a rapid and specific method of screening for CO exposure. During the winter months, elevated CO levels are present in over 7% of ED patients presenting with headaches.

The author has no potential financial conflicts of interest to report.

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