

RESEARCH ARTICLE

Trends and characteristics of cases when serial carboxyhemoglobins are obtained

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ABSTRACT

Background: Carboxyhemoglobin (COHb) levels are obtained when there is suspicion for carbon monoxide (CO) exposure. Serial COHb levels are sometimes obtained despite the well-established half-life of COHb with oxygen supplementation. We sought to evaluate the trends and characteristics associated with obtaining serial carboxyhemoglobin levels.

Methods: A retrospective review was performed at an academic medical center for all inpatient and emergency department cases with either single COHb or serial COHb levels from 1 April 2010 through 31 March 2015. Data collected included age, gender, pregnancy status, smoking history, encounter month, admission status, oxygen administration, fire or burn history, vital signs, presenting symptoms, hyperbaric oxygen (HBO₂) therapy use, initial pH, troponin, lactate, and COHb levels. The time and change in values between serial levels were also obtained.

Results: 624 cases were identified, with 106 (17%) having multiple carboxyhemoglobin levels. A mean of 2.6 (range 2 - 9) serial COHb levels were obtained. The average initial COHb was 8.9%. Subsequent serial levels were obtained on average at 353, 663 and 1,095 minutes and averaged 2.8%, 1.8% and 1.1% respectively. Serial COHb levels were obtained more commonly in burn patients, those admitted to the ICU and those who had HBO₂ therapy. Four patients had an increase in COHb level on serial testing. The largest increase of these was from 2.0% to 3.9%.

Conclusion: Serial COHb levels were not infrequent in this study. No clinically significant increase in COHb was identified by serial testing. Further studies should examine the clinical utility of such practices. ■

INTRODUCTION

Carbon monoxide (CO) exposures are frequently seen in the emergency department [1]. CO poisoning is among the most common accidental poisonings in the United States, accounting for up to 50,000 emergency department visits and 1,300 deaths per year [1,2]. CO is not detectable by any human sense, and symptoms of CO exposures are vague and non-specific. These include headache, nausea and vomiting in more mild cases, with syncope, ataxia, chest pain, visual disturbances, and focal neurologic deficits seen in more severe cases [3]. At times presenting symptoms can be severe, including coma or cardiopulmonary arrest [3].

Diagnosis of carbon monoxide poisoning is clinical, but acute exposure to carbon monoxide can be confirmed by demonstrating an elevated blood carboxyhemoglobin (COHb). COHb is formed when CO binds to hemoglobin, which it does so with an affinity of up to 210-250 times greater than oxygen [4].

The preferred method of detecting COHb is by testing arterial or venous blood samples with a laboratory CO-oximeter. Standard pulse oximetry cannot accurately detect COHb and may provide false reassurance to providers by measuring falsely elevated oxyhemoglobin saturations in patients with true carbon monoxide poisoning

KEYWORDS: carbon monoxide; carboxyhemoglobin; hyperbaric oxygen therapy; research

Table 1: Comparison of multiple COHgb vs. single COHgb cases.

	multiple COHgb (n=106)	single COHgb (n=515)	p-value
average age (range)	49.8 (9-88)	47 (1-98)	.3636
percent male (n)	63.2 (67)	62.0 (321)	.3948
percent smokers (n)	46.2 (49)	40.5 (210)	.8346
mean initial COHgb (range)	9.0 (0.2-45.2)	3.0 (0-40.6)	.3883
percent burn Injury (n)	64.2 (68)	50.0 (259)	.0103
percent admitted (n)	86.8 (92)	75.3 (390)	.0001
percent ICU admit (n)	64.2 (68)	35.1 (182)	.0001
percent receiving HBO ₂ therapy (n)	14 (15)	3.5 (18)	.0001
death (n)	7.5 (8)	5.4 (28)	.3675

[5]. New multiwave pulse CO-oximetry tools designed to detect carboxyhemoglobin are available. Some studies have questioned their accuracy and there is concern they may overestimate carboxyhemoglobin levels when compared to conventional laboratory CO-oximetry [6].

COHb is a very stable complex. In patients breathing room air COHb has been demonstrated to have a half-life of approximately four to six hours [7]. However, this can be decreased to approximately 80 minutes in response to breathing 100% normobaric oxygen or approximately 20 minutes if receiving hyperbaric oxygen [7,8].

Despite the well-established kinetics of COHb elimination, serial COHb levels are often obtained in clinical practice. We sought to evaluate the results and clinical characteristics of cases where serial COHb levels were obtained.

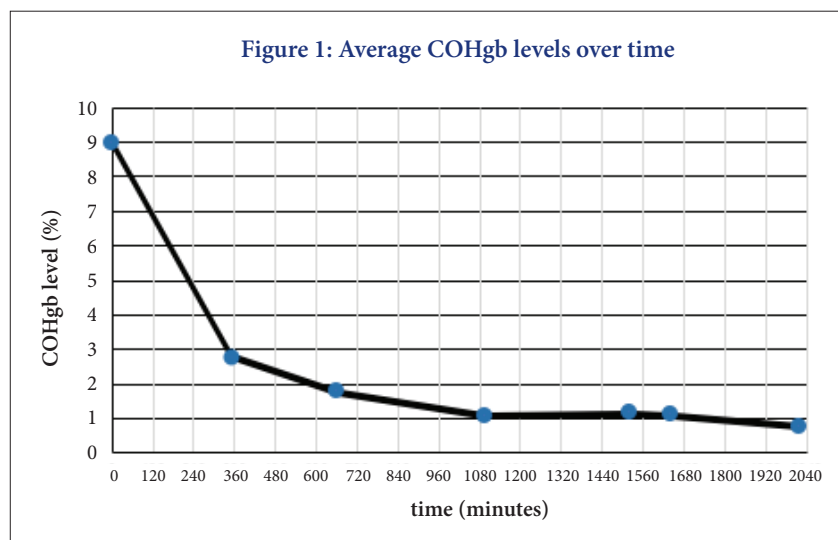
METHODS

This study was an IRB-approved retrospective chart review of the emergency department and inpatient charts of a 650-bed quaternary care level 1 trauma academic medical center with a burn unit and an emergent hyperbaric oxygen therapy unit in Kansas City, Kansas. In this institution COHb levels are ordered and resulted as an individual lab and not as part of a blood gas panel. Patients being evaluated for acute CO exposure with at least one carboxyhemoglobin level, either venous or arterial, obtained during the time span of 1 April 2010 through 31 March 2015 were included in the study. Patients who had carboxyhemoglobin levels drawn and who were being evaluated for transplantation or for pulmonary function

testing were excluded from the study. Data was abstracted by the authors. Inter-rater reliability was assured through training and evaluation of Kappa scores which after two training periods was 0.9 among all reviewers. Data was collected via a standardized data collection tool. Collected data included age, gender, pregnancy status, smoking history, month of encounter, admission level of care, administration of oxygen, history of fire or burn, vital signs, presenting symptoms, use of hyperbaric oxygen (HBO₂) therapy, initial pH, and troponin, lactate and carboxyhemoglobin levels. Cases with serial COHb levels were further identified; the timing of each level was also obtained and delta-times were calculated. For this study a COHb level of >2% was considered abnormal for non-smokers and >5% for smokers [9]. Statistical calculations were performed using Microsoft Excel (Redmond, Washington, U.S.).

RESULTS

The search identified 2,213 cases. Of this group 624 cases had an associated ED or inpatient encounter where there was a concern for acute CO exposure. The other cases were transplantation or pulmonary function testing patients and were excluded, as they were not being evaluated for possible carbon monoxide exposures. A total of 106 (17%) of cases who met inclusion criteria had multiple carboxyhemoglobin levels obtained during their encounter. Table 1 compares the characteristics of the cases with multiple COHb results versus those with a single COHb result. The mean number of COHb levels obtained was 2.6 (range 2-9), with a total of 167 COHb levels obtained after the initial COHb result. Figure 1 demonstrates the



trend of serial COHb levels over time. The average initial level was 9.0% (SD 10.0). Subsequent levels averaged 2.8% (SD 3.3) at 353 minutes; 1.8% (SD 1.8) at 663 minutes; 1.1% (SD 0.94) at 1,095 minutes; 1.1% (SD 0.71) at 1,525 minutes; 1.1% (SD 0.86) at 1,644 minutes; and 0.75% (SD 0.05) at 2,023 minutes. The longest interval time between initial and final serial COHb was 3,807 minutes (2.6 days) in one case where a total of four levels were obtained.

Four patients were identified as having a change in carboxyhemoglobin level from normal (defined as <2% by the institution lab) to abnormal on serial levels. The largest interval increase was from 1.9% to a level of 3.9%. All four of these patients were current smokers: Three were presenting for burn injuries and one was presenting with altered mental status. None of their carboxyhemoglobin levels exceeded 4% at any time, and none of the four died. There were 36 deaths (28 in the single COHb group and eight in the serial COHb group) in this study but no difference in mortality rates between the two groups. HBO₂ therapy was utilized in 32 cases (5%), including 15 times in the serial COHb group. Of these 15, 66% (n=10) had COHb levels checked after HBO₂, which resulted in 1.3% (range 0.2% -3.5%).

DISCUSSION

Exposure to carbon monoxide is among the most commonly encountered poisonings [10]. The measurement of COHb remains the gold standard test to identify acute CO exposures [11]. Despite its widespread use the actual prognostic value of any particular COHb level is unclear [12]. It is even less clear if there is any clinical value

in obtaining serial COHb levels. The elimination half-life of COHb under various conditions has been well studied and is predictable to within a narrow time range [8]. Thus, barring a concern for ongoing exposure to CO, repeating COHb levels in the acute care setting would appear to have little clinical value.

This study demonstrated that obtaining serial COHb levels was not rare, occurring in 17% of possible CO exposure cases. The practice of obtaining serial COHb levels was more commonly seen in burn victims and those admitted both to the hospital and the ICU. Not surprisingly, the results of the serial COHb levels demonstrated a consistent decline. We could not identify any case where a repeat COHb testing resulted in identifying a significant COHb increase. In no cases where initial COHb was elevated did a subsequent COHb result in an increased level. Ironically, patients with serial COHb levels were also more likely to receive HBO₂ even though HBO₂ therapy would reduce the elimination half-life of COHb to approximately 20 minutes. Considering that typical HBO₂ treatments are longer than two hours, post-HBO₂ COHb levels would never be expected to be abnormal. Not surprisingly, all post-HBO₂ COHb measurements in this study were normal.

This study was not designed to assess the economic impact of serial COHb testing. The cost of performing COHb testing and the charge to patients will vary between institutions though the Centers for Medicare and Medicaid report a reimbursement of rate of \$14.07 per test [13]. Similarly, this study was not designed to detect the impact of serial COHb testing on length of stay.

LIMITATIONS

This study has several limitations. It is a retrospective study and is subject to the possibility of incomplete charting. In addition, it was performed at a single center, and external validity may be limited. Only COHb levels obtained at our institution were recorded. We did not record if a patient had a COHb level drawn at an outside facility prior to transfer. Finally, we could not rule out that some patients may have continued to smoke tobacco while admitted, thus elevating their COHb levels.

CONCLUSION

Serial COHb levels were not infrequent in this study. No clinically significant increase in COHb was identified by serial testing. Serial COHb tests were more likely to be ordered on patients with burns and those admitted to the hospital and ICU. Further studies should examine the clinical utility of such practices. ■

Conflict of interest statement

The authors declare no conflict of interest exists with this submission.

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