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Original Contributions

Trends in the incidence of carbon monoxide poisoning in the United States

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Abstract

Purpose: Recent data demonstrate that the mortality rate from carbon monoxide poisoning has declined over the past 2 decades. It is not known whether this decrease in mortality is reflective of the total burden of carbon monoxide poisoning. This study sought to examine trends in other potential indicators of the incidence of carbon monoxide poisoning in the United States.

Basic Procedures: Published data from US poison control centers (PCCs) were used to calculate annual rates of calls regarding carbon monoxide exposures. Data on numbers of carbon monoxide–poisoned patients treated with hyperbaric oxygen (HBO) were used to calculate annual treatment rates. Trends in rates of carbon monoxide–related mortality, calls to PCCs, and HBO treatment were then compared.

Main Findings: Contrary to the decline in carbon monoxide–related mortality from 1968 to 1998, rates of calls to PCCs significantly increased over the same period. Neither rates of PCC calls nor HBO treatment changed significantly from 1992 to 2002. The latter 2 measures were strongly correlated.

Principal Conclusions: Although deaths from carbon monoxide poisoning have clearly decreased in the United States, other indicators of the incidence of the condition suggest that the total burden (fatal and nonfatal) may not have significantly changed. Efforts to prevent carbon monoxide poisoning should not be relaxed.

1. Introduction

Carbon monoxide poisoning is common in the United States, accounting for an estimated 40 000 to 50 000 ED visits annually [1]. Exposure to carbon monoxide can be either intentional (suicidal) or unintentional (accidental). It is generally believed that unintentional carbon monoxide poisoning may be partially preventable through public education programs and/or governmental regulations. In support of this concept, a recent study reported a decline in carbon monoxide–related mortality rates from 20.2 to 8.8 deaths per million person years during the period 1968 to 1998 [2]. Most of this reduction occurred in unintentional motor vehicle–related carbon monoxide poisoning deaths and correlated with the introduction of the catalytic converter to automobiles in 1975.

Although trends such as these may suggest that the problem of carbon monoxide poisoning has been solved, it should be recognized that such data represent only fatal episodes. Because nonfatal carbon monoxide poisoning can result in significant long-term morbidity even when treated appropriately [3], this study was conducted to determine

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whether declining death rates are reflective of all forms of carbon monoxide poisoning. To do this, trends in 2 other potential indicators of the disease burden in the United States, specifically (1) calls to poison control centers (PCCs) regarding cases of carbon monoxide exposure and (2) national rates of hyperbaric oxygen (HBO) treatment of carbon monoxide poisoning, were examined and compared.

2. Methods

Summary information on calls to US PCCs are published yearly in the *American Journal of Emergency Medicine* as the Annual Report of the American Association of Poison Control Centers Toxic Exposure Surveillance System. Reports containing data from 1985 to 2002 were searched for the total number of calls received regarding cases of carbon monoxide exposures [4-21]. Participating centers also report the size of the population that they serve, allowing calculation of the rate of calls for carbon monoxide exposure per million person population per year.

Information on the number of patients treated with HBO for carbon monoxide poisoning was collected in a recent survey of US HBO treatment facilities [22]. In that survey, treatment data for the years 1992 to 2002 were requested from the 320 known hyperbaric facilities in the country, with responses obtained from 310. Full methodological details are available in that publication. For the present comparison, annual HBO treatment rates were calculated by dividing the total number of yearly treatments by US Census Bureau population estimates, using the national resident midpoint population estimates for each year [23,24].

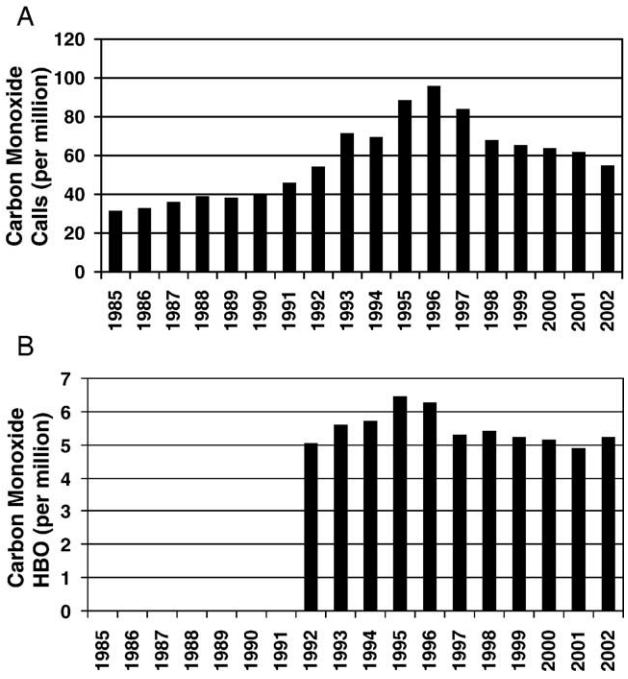

Fig. 1 A, Calls to US PCCs annually regarding cases of carbon monoxide exposure (per million population served). B, Patients in the United States treated annually with HBO for carbon monoxide poisoning (per million population).

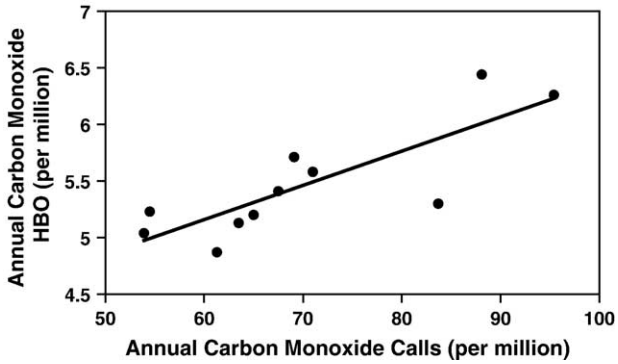

Fig. 2 Correlation of annual rates of PCCs calls regarding carbon monoxide exposures with rates of patients treated with HBO for carbon monoxide poisoning during the years 1992 to 2002.

For each of the 2 data sets, linear regression was used to calculate a best-fit line through the annual rates and then to determine whether the slope was significantly different than zero, which would indicate a positive or negative change over the period studied. Comparison of trends in annual rates for poison center calls and HBO treatment for the overlapping years of 1992 to 2002 was performed using linear regression analysis.

3. Results

Annual call rates to US PCCs regarding cases of carbon monoxide exposure are displayed in Fig. 1A. Call rates rose from 31.1 per million persons served in 1985 to 95.4 per million persons served in 1996 and then fell to 54.5 per million persons served in 2002. Over the entire 18 years, there was a significant increase in the rate of calls ($P = .0022$). From 1985 to 1998, years for which mortality rate data are available, there was an increase in call rate from 31.1 to 67.5 per million persons served ($P < .0001$). From 1992 to 2002, years for which comparative hyperbaric treatment data are available, there was no significant change in the rate of calls ($P = .3975$).

Hyperbaric oxygen treatment rates for carbon monoxide poisoning rose from 1992 to 1995, then generally declined from 1995 to 2002, as shown in Fig. 1B. Similar to poison center calls for the period, there was no significant overall change in the rate of hyperbaric treatment ($P = .1946$). However, rates of calls to PCCs and rate of hyperbaric treatment of carbon monoxide poisoning were strongly correlated ($r = 0.8209$, $P = .0020$) (Fig. 2).

4. Discussion

Mortality from carbon monoxide poisoning has declined in the past 2 decades, driven largely by a reduction in deaths

from accidental exposure to automobile exhaust [2]. As speculated by the authors of that study, the 1970 Clean Air Act has probably played a large role in this by reducing carbon monoxide levels in automobile exhaust emissions. Although this should be seen as a definite accomplishment, the present study suggests that nonfatal carbon monoxide exposures have not decreased and that efforts toward prevention of carbon monoxide poisoning should not be allowed to relax.

As seen in Fig. 1A, calls to US PCCs regarding cases of carbon monoxide exposure did not decrease in the same period. In fact, the rate of calls steadily increased from 1985 to 1996, whereas the mortality rate fell. Since 1996, calls have declined, but there was no net change from 1992 to 2002. One possible reason for this lack of correlation with mortality rates is that calls to PCCs are generally with regard to nonfatal poisonings. Centers are contacted for advice on poisoning management. If an individual is found deceased, a poison center is not typically involved. Support for this concept comes from the same data set as the information on call rates [4-21]. The annual reports also list the number of calls regarding cases that ultimately become fatalities. From 1985 to 2002, there were 227 896 carbon monoxide exposure calls reported with only 551 deaths (0.2%).

An alternate explanation for the lack of correlation between carbon monoxide exposure reports and the declining mortality rate could be that reporting has simply improved over time and that the number of nonfatal carbon monoxide poisoning cases has actually decreased as well. To differentiate which explanation is correct, we compared the trends with a third possible indicator of disease burden, hyperbaric treatment of carbon monoxide poisoning. Hyperbaric oxygen is generally used to treat the most severely poisoned subset of patients [25]. It has been estimated that approximately 6% of carbon monoxide–poisoned patients seen in EDs nationally are treated with HBO [1]. As long as the spectrum of severity of the condition and treatment practices has not been recognized to have changed significantly during the period surveyed, the national rate of HBO treatment should serve as a qualitative marker of total disease incidence.

As is seen in Fig. 1B, hyperbaric treatment rates fluctuated over the decade studied but did not significantly change overall. Furthermore, the strong correlation between poison center calls and hyperbaric treatment rates suggest that both are valid indicators of the same group of patients, those with nonfatal carbon monoxide poisoning.

It would thus appear that the declining death rate from carbon monoxide poisoning might not tell the entire story. Two indicators of nonfatal poisoning have not significantly changed in recent years. Because fatalities represent only a small fraction of the total poisoned population, it is not unreasonable to speculate that the total number of individuals poisoned with carbon monoxide nationally may not have significantly decreased in the past 2 decades. A declining mortality rate from the condition is very laudable, but it should not be used as evidence that efforts to prevent carbon monoxide poisoning can be relaxed.

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