# Hyperbaric treatment of patients with carbon monoxide poisoning in the United States.

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Hampson NB, Little CE. Hyperbaric treatment of patients with carbon monoxide poisoning in the United States. Undersea Hyperb Med 2005; 32(1):21-26. Introduction: Hyperbaric oxygen ($HBO_2$) is effective therapy for carbon monoxide (CO) poisoning. In recent years, many hyperbaric physicians in the US have felt that numbers of patients referred for treatment of CO poisoning have decreased. Further, since the 2002 Weaver et al study (5), there has been discussion regarding the best treatment protocol. This study was conducted to determine numbers of patients treated with $HBO_2$ annually over the past decade in the US and whether there is a consensus about the number of treatments per patient. Materials and Methods: A survey was mailed to all US facilities listed in the 2001 UHMS Chamber Directory. Two subsequent mailings were sent to survey nonresponders, followed by telephone contacts. Results: Of the 320 facilities listed in the directory, 10 were nonresponders, 26 had closed since publication and 80 do not treat CO poisoning, leaving 204 facilities. From 1992-2002, a total of 16,367 patients were treated with $HBO_2$ for CO poisoning, an average of 1,488 $\pm$ 121 patients/year (mean $\pm$ SD). While the total number of patients treated annually did not decrease during the period studied, the number treated per facility did decline as a result of an increase in number of treating facilities. Only 46 facilities (23%) automatically give more than 1 hyperbaric treatment per CO-poisoned patient. Among those that do, 20 facilities (10%) give 3 treatments per patient. Conversely, 136 (67%) sometimes give more than one treatment and 12 facilities (8%) never retreat. Conclusions: Approximately 1,500 CO-poisoned patients are treated with $HBO_2$ in the US annually, a number that has remained relatively constant since 1992. The majority of facilities does not routinely give more than one hyperbaric treatment, but will give repetitive treatment in certain situations.

## INTRODUCTION

Hyperbaric oxygen ($HBO_2$) therapy is effective treatment for selected patients with acute carbon monoxide (CO) poisoning (1). In recent years, however, many hyperbaric physicians in the United States have expressed the impression that the number of patients referred for $HBO_2$ treatment of CO poisoning has decreased.

Further, there has recently been renewed discussion regarding the appropriate hyperbaric treatment protocol for the condition. The majority of prospective, controlled clinical trials investigating $HBO_2$ treatment of CO poisoning have demonstrated effectiveness of the therapy over normobaric oxygen treatment (1). However, each of the four positive studies has used a different hyperbaric treatment protocol (2,3,4,5). Most notable among these differences is the fact that the 2002 study by Weaver and colleagues administered three treatments per patient (5). This has led many in the field to question whether more than one $HBO_2$ treatment should automatically be given to each patient treated for CO poisoning.

This study was conducted to determine (1) the numbers of patients in the US treated annually with $HBO_2$ for CO poisoning over the past decade, (2) the type of hyperbaric chamber utilized for treatment, and (3) whether there is consensus with regard to the number of treatments that should be administered per patient.

## METHODS

In early 2003, a one-page survey was mailed to all United States hyperbaric facilities listed in the 2001 Chamber Directory of the Undersea and Hyperbaric Medical Society (6). Facility medical directors and/or nurse managers were asked the following questions:

1. Do you treat patients with CO poisoning with hyperbaric oxygen at your facility?
2. What type of chamber do you use to treat them (monoplace vs. multiplace)?
3. How many patients with CO poisoning did you treat with $HBO_2$ annually from 1992-2002?
4. Are there any factors that you believe have influenced the number of CO-poisoned patients referred for $HBO_2$ therapy in recent years?
5. Do you automatically give more than one hyperbaric treatment to CO-poisoned patients? If so, how many treatments do you give? If not, do you ever give more than one treatment to a patient with CO poisoning?

Two subsequent mailings were sent to survey nonresponders, followed by telephone contacts as necessary to obtain a high response rate.

Simple descriptive statistics were used for analysis and reporting of data. The Institutional Review Board of Virginia Mason Medical Center, Seattle, approved the study.

## RESULTS

Of the 320 US facilities listed in the directory, 10 were survey nonresponders, yielding an overall 97% response rate to the survey (Figure 1). Among the 310 responders, 26 facilities had closed operations since directory publication and 80 do not treat CO poisoning. The remaining 204 responding, treating facilities comprised the population from which further study data were obtained. Of these, 148 (73%) utilize a monoplace hyperbaric chamber to treat patients with CO poisoning and 56 (27%) use a multiplace chamber. From 1992 through 2002, a total of 16,367 patients were treated with $HBO_2$ for CO poisoning at the responding facilities, an average of 1,488 $\pm$ 121 patients per year (mean $\pm$ SD) (Table 1 and Figure 2). A total of 8,547 patients were treated in monoplace facilities and 7,820 in multiplace facilities. Over the period studied, the number treated ranged from 1,291 to 1,714 annually. Individual monoplace facilities treated from 1 to 109 patients per year, while multiplace facilities treated from 1 to 175 patients per year.

**Fig. 1.** Response results from hyperbaric facilities surveyed.

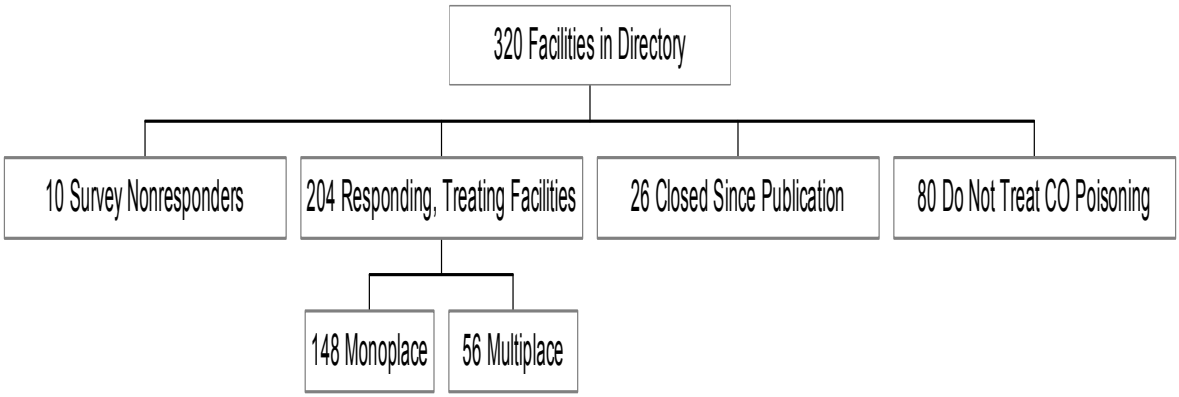
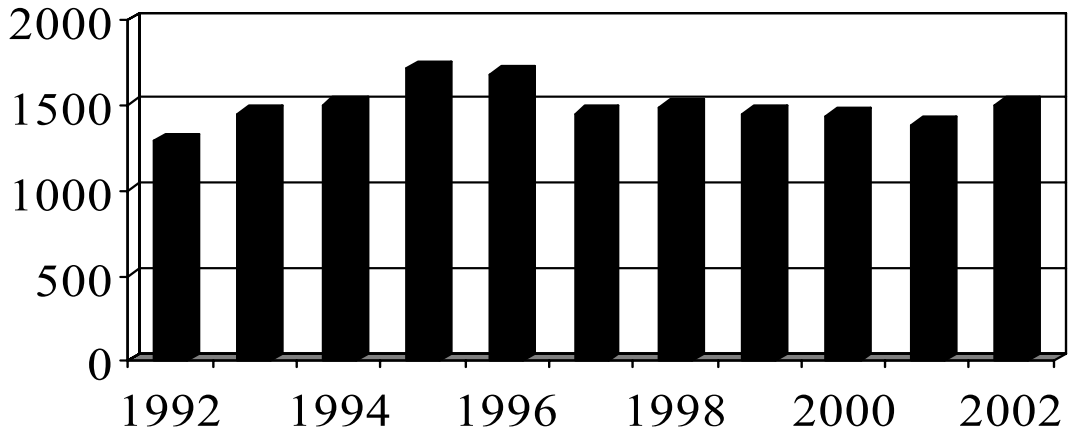


**Table 1**. Patients with CO poisoning treated annually in the US.

| | Number of patients treated with $HBO_2$ | Number treated in monoplace chambers | Number treated in multiplace chambers | Total number of treating facilities | Mean number treated per facility |
|---|---|---|---|---|---|
| 1992 | 1291 | 617 | 674 | 70 | 18.4 |
| 1993 | 1450 | 711 | 739 | 73 | 19.9 |
| 1994 | 1502 | 817 | 685 | 80 | 18.8 |
| 1995 | 1714 | 888 | 826 | 87 | 19.7 |
| 1996 | 1684 | 900 | 784 | 92 | 18.3 |
| 1997 | 1448 | 810 | 638 | 101 | 14.3 |
| 1998 | 1492 | 838 | 654 | 114 | 13.1 |
| 1999 | 1452 | 705 | 747 | 126 | 11.5 |
| 2000 | 1441 | 746 | 695 | 140 | 10.3 |
| 2001 | 1388 | 735 | 653 | 151 | 9.2 |
| 2002 | 1505 | 780 | 725 | 144 | 10.5 |

**Fig. 2.** Number of patients with carbon monoxide poisoning treated with hyperbaric oxygen annually in the United States from 1992 to 2002.




While the total number of patients treated annually did not decrease during the period studied, the number treated per facility did decline as a result of an increase in number of treating facilities (Table 1). In 1992, a total of 70 facilities reported that they treated CO-poisoned patients. A decade later, 144 facilities treated patients in 2002. As such, the number of patients treated per facility annually decreased from 18.4 to 10.5 over that period.

The responses were quite varied to the question if any factor had influenced the number of CO-poisoned patients referred for $HBO_2$ therapy in recent years. Among facilities experiencing lower referrals, common reasons included poor education of local emergency medical providers, increasing

numbers of chambers in the area, publication of conflicting or negative studies about efficacy of $HBO_2$ for CO poisoning, and prevention of poisoning through public education and/or use of CO detectors. Among facilities experiencing increasing referrals, common reasons included improved education of local emergency medical providers, closure of other regional hyperbaric facilities, publication of the positive study on hyperbaric treatment of CO poisoning by Weaver (5), and local epidemics of CO poisoning related to severe storms.

Only 46 of 204 treating facilities (23%) automatically give more than one hyperbaric treatment to each CO-poisoned patient. Among those that do, the number of treatments per patient range from 2 to 14 (Table 2), and most administer 2 (39%) or 3 (43%) treatments per patient (Table 2). Conversely, 136 (67%) facilities indicated that they sometimes give more than one treatment and 12 facilities (8%) never retreat a CO-poisoned patient.

**Table 2.** Number of treatments given by 46 facilities automatically administering more than one hyperbaric treatment to every CO-poisoned patient.

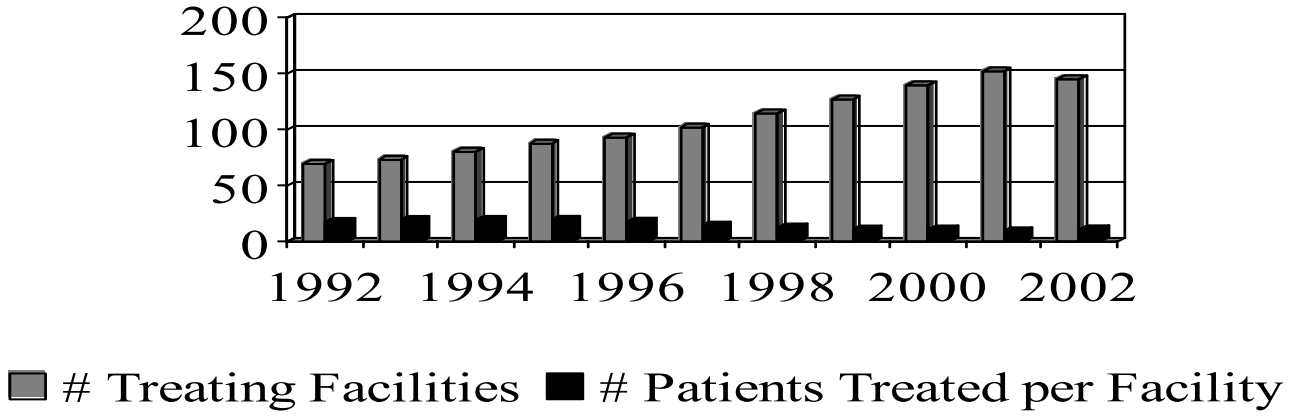
| Number of Treatments Administered per Patient | Number of Facilities |
|---|---|
| 2 | 18 |
| 3 | 20 |
| 4 | 1 |
| 5 | 5 |
| 10 | 1 |
| 14 | 1 |

## DISCUSSION

Results of this study show that approximately 1,500 CO-poisoned patients are treated with $HBO_2$ in the US annually and that the number has remained relatively constant since 1992. Two possibilities may explain why many hyperbaric physicians have the impression that patients referrals for treatment of CO poisoning have declined in recent years. First, there were atypically high numbers of patients treated nationally in 1995 and 1996 (Table 1, Figure 2). If a relatively short-term perspective is used, the number of patients treated has indeed decreased since the mid-1990s. However, the longer perspective of a decade demonstrates that the number treated has actually remained relatively stable.

Second, a real decrease in number of patients treated per facility over the past decade has occurred. This is due to an increasing number of treating facilities, not to a decrease in total patients treated (Figure 3). The number of facilities increased steadily from 1992 to 2001, more than doubling over that time. As they shared a relatively constant population of patients, it is not surprising that the number treated per facility has decreased by approximately 50%.

**Fig. 3.** Number of hyperbaric facilities treating patients with CO poisoning annually in the US and average number of patients treated per facility.




When facility medical directors and/or nurse managers are asked to why they think referrals for CO poisoning have changed, approximately half offer reasons that suggest a belief that referrals have declined while half give reasons suggesting an increase. Both groups see education as a powerful influence. Examples include likelihood of emergency department referral for $HBO_2$ depending on the educational level of emergency department staff about the condition and prevention of CO poisoning by improved patient education. The conflicting nature of published studies in the past decade was reported by some as a negative influence, while several respondents suggested that the study by Weaver (5) was a strong positive influence. Not surprisingly, a change in the number of regional treating facilities was noted to influence the number of patients referred to any one facility. Finally, many believe that CO detectors are effectively preventing CO poisoning and thereby reducing the number of patients referred.

The majority of facilities treating CO poisoning do not routinely give more than one hyperbaric treatment for the condition, but most will give repetitive treatment in certain situations. Monoplace facilities were approximately twice as likely as multiplace to automatically administer more than one treatment (27% vs. 14%, respectively). In the case of the remaining multiplace facilities, 75% sometimes retreat and 11% never retreat.

A 1992 survey of treatment practices for CO poisoning at North American multiplace hyperbaric facilities found that 76% sometimes retreated patients for the same episode of CO poisoning, while 24% never retreated patients (7). As the present survey was performed in 2003, these results suggest that the study reported by Weaver in 2002 did change practice patterns toward repetitive treatment, at least among multiplace facilities.

Approximately one-quarter of all treating facilities give more than one treatment to all patients. When they do, the number given is quite variable (Table 2). One can only speculate how each of these protocols was established. Most which treat more than once administer either 2 or 3 treatments. With regard to 2 treatments per patient, a retrospective, non-randomized study by Gorman published in 1992 suggested better clinical outcome in those patients who received at least 2 treatments, as compared to only 1 treatment (8). As mentioned earlier, the Weaver study applied 3 treatments per patient, possibly influencing practice among those who

utilize this protocol. The authors are not aware of any reported studies that suggest routine administration of 4, 5, 10, or 14 treatments per patient. It should be noted that, despite the extremely high quality of Weaver's study, 3 treatments per patient are routinely administered by only 10% of treating facilities. It should also be remembered that while Weaver utilized 3 treatments, he did not compare that number to 1 treatment. At this time, the standard of care for CO poisoning in the US appears to be one hyperbaric treatment, repeated if deemed clinically necessary.

In summary, the total number of patients treated with $HBO_2$ for CO poisoning in the US has not changed significantly over the past decade. Because the number of hyperbaric facilities treating the condition has increased, the average number of patients treated per facility has decreased, probably explaining the impression of some that numbers of CO-poisoned patients referred for $HBO_2$ have declined. Roughly equal numbers of patients are treated in monoplace and multiplace chambers. The majority of treating facilities do not automatically administer more than one treatment per patient. The fact that disparity with regard to treatment protocol exists confirms previous recommendations that prospective trials are still needed to clarify the therapeutic approach to CO poisoning (1).

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