The World as it is

Requests for emergency hyperbaric oxygen treatment for carbon monoxide poisoning in Ankara, Turkey

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Abstract

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Background: Carbon monoxide (CO) poisoning is common in Turkey. Our department is the main provider of emergency hyperbaric oxygen therapy (HBOT) in Ankara and neighboring cities. In this study, we analyzed the characteristics of CO-poisoned patients who were referred by phone to our department for emergency HBOT.

Methods: We retrospectively reviewed the records of phone consultations with emergency departments regarding the need for treatment of CO-poisoned patients with HBOT between 14 January 2014 and 14 January 2015. The following information was extracted from medical records: age, gender, CO source, exposure duration, carboxyhemoglobin (COHb) level, symptoms, electrocardiography (ECG) findings, cardiac enzymes, pregnancy, the distance of referring hospital to our centre, time between admission and consultation and HBOT decision.

Results: Over the one-year period, 562 patients with CO poisoning were referred for HBOT. We recommended HBOT for 289 (51%) patients. HBOT was recommended for 58% (n = 194) of the patients with COHb ≥ 25%, 72% (n = 163) of the patients with a history of syncope, 67% (n = 35) of the patients with ECG abnormality, and 67% (n = 14) of pregnant patients. Patients for whom HBOT was not recommended despite having positive signs of severe poisoning were referred significantly later compared to patients for whom HBOT was recommended.

Conclusion: We found that the duration from admission to an emergency department to HBOT consultation affected our decision-making.

Key words

Toxicity; transport; hyperbaric medicine; clinical audit

Introduction

Carbon monoxide (CO) poisoning is a leading cause of morbidity and mortality worldwide.[1–6] According to Social Security Agency records, in 2010 10,154 patients presented to emergency departments (ED) in Turkey for CO poisoning. A frequency of 14/100,000 and a mortality rate of 5/10,000,000 was calculated. However, these rates may be an underestimate of the actual figures considering the misdiagnosis of these cases at EDs and the people deceased at the scene who never reach an ED.[7]

CO strongly binds to oxygen-binding sites on haemoglobin and forms carboxyhaemoglobin (COHb) which eventually causes tissue hypoxia by reducing the oxygen-carrying capacity of the blood. The CO-haemoglobin bond can be reversed by supplemental oxygen therapy. Normobaric oxygen therapy with a non-rebreathing face mask is the standard treatment for CO poisoning. Hyperbaric oxygen treatment (HBOT) is recommended in severe cases to minimise long-term and permanent neurocognitive dysfunction.[8–10]

Currently, there is no clear consensus on HBOT indications for CO poisoning. According to the Undersea and Hyperbaric Medical Society (UHMS), patients with serious CO poisoning (as manifested by transient or prolonged unconsciousness, abnormal neurologic signs, cardiovascular dysfunction, or severe acidosis) or patients who are 36 years of age or older, those exposed to CO for 24 hours or more (including intermittent exposures), pregnant patients or those with COHb level of 25% or more are recommended to receive HBOT.[11] Similarly, the European Committee for Hyperbaric Medicine (ECHM) recommends HBOT to patients with a high risk of immediate or long-term complications. Unconsciousness at or before admission, clinical neurological, cardiac, respiratory or psychological symptoms or signs and pregnancy were identified as high risk factors. If a patient's symptoms have ceased and HBOT was delayed beyond 24 hours after the last exposure, HBOT is not generally recommended.[12] On the other hand, the American College of Emergency Physicians does not mandate any particular practice.[13]

Our department is the main provider of emergency HBOT in Ankara and neighboring cities in Turkey. We have an on-call team for emergency referrals 24/7. Our on-call team decides whether to accept a patient for emergency HBOT based on the information provided by the referring hospital on the phone. Our department does not have predefined criteria for HBOT in CO poisoning, although we take into account the recommendations of UHMS and ECHM. Owing to the limited availability of HBOT centres in Turkey, patients must to be transferred between hospitals, even between cities, for emergency HBOT. Thereby, transportation-related risks and the distance between a hospital and HBOT facility are other important factors that should be considered for HBOT decisions.

In this study, we analyzed the characteristics of CO-poisoned patients who were referred to our department for emergency HBOT. Additionally, we evaluated the frequency for which HBOT was recommended for each criterion. No attempt to assess clinical outcome was made in this review.

Methods

We retrospectively reviewed the records of telephone consultations with EDs regarding the need for HBOT for CO-poisoned patients between 14 January 2014 and 14 January 2015. The study protocol was approved by the Institutional Ethics Committee for Clinical Research. Informed consent was not required since the telephone consultation records were anonymous. The following information was extracted from the phone consultation records: patient's age and gender, CO source, exposure duration, COHb level, symptoms, electrocardiography (ECG) findings, cardiac enzymes and pregnancy. The distance of the referring hospital to our centre and the elapsed time between emergency admission and HBOT consultation were also analyzed.

The data are reported as n (%) or mean ± standard deviation (SD). The patients with missing data for some parameters were not excluded. The missing data were taken into account while calculating the percentages and reported separately. For statistical analysis, we used independent samples t-tests for continuous variables and chi-square tests for categorical variables. A value of $P < 0.05$ was accepted as statistically significant. We used SPSS® Statistics Version 21 (IBM Corp., Armonk, NY) for statistical analysis.

Results

The telephone consultation records included 562 patients over the one-year period. Of these, 177 (31%) were female, and 241 (43%) were male, while the gender information was missing for 144 (26%) patients. The mean age of the patients was 28.6 ± 22.4 years (range: 0.1–88 years). The mean COHb level of the patients was 27.6% (range: 0.4%–70%), while the COHb level was unknown in 32 patients. The mean CO exposure duration was 7 ± 6 hours (n = 109; range: 1–24 h). The mean elapsed time between emergency unit admission and HBO consultation was 3h 22 min ± 3h 14 min (range: 15 min–19 h 40 min). The clinical characteristics of referred patients are summarised in Table 1.

Table 1
Clinical characteristics of patients referred for hyperbaric oxygen treatment (HBOT)

	n	(%)
Most common symptoms		
History of syncope	225	(40)
Headache	86	(15)
Nausea/vomiting	56	(10)
Dizziness	28	(5)
Other neurological symptoms		
Confusion	26	(5)
Lethargy	26	(5)
Loss of consciousness (+ respiratory difficulties)	18	(3)
Loss of consciousness	14	(2.5)
Seizure	9	(1.6)
Incontinence	8	(1.4)
ECG abnormalities		
Yes	52	(9)
No	431	(77)
Not available	79	(14)
Cardiac enzyme abnormalities		
Yes	70	(13)
No	327	(58)
Not available	165	(29)
Pregnancy		
Yes	21	(4)
% Carboxyhemoglobin		
0–24%	195	(34.7)
≥ 25%	335	(59.6)
Not available	32	(5.7)

Among all consultations, 10% were from our institution, 58% were from other hospitals in Ankara and 31% were from 24 other cities. The average distance between consulting cities and Ankara was 285 ± 127 km (range: 80–737 km). The patients were mostly referred in the winter months of December through February (58%) and after working hours (63%). The most frequent CO sources were heating systems including stoves (53%) and combi gas boilers (27%).

We recommended HBOT for 289 (51%) patients. The mean COHb level of the patients for whom HBOT was recommended was 30.4% (± 10.7%; range:1%–70%) and was significantly higher than in those for whom HBOT was not recommended (24.8% ± 9.2%, range: 0.4%–53.0%; P = 0.029). When the patients were grouped according to their COHb level, 58% of the patients with COHb ≥ 25%, were recommended to receive HBOT whilst 40% of the patients with COHb ≤ 25% were recommended to receive HBOT ($P < 0.001$).

A history of syncope was present in 40% (n = 225) of patients and 72% (n = 163) of them were recommended to receive HBOT ($P < 0.001$; Table 2). Among the patients (n = 108)

Table 2
The rate of recommendation for hyperbaric oxygen treatment (HBOT) based on commonly used criteria

	HBOT		No HBOT		*P* value
Age group (years)					
0–35	184	(52)	168	(48)	0.331
>35	92	(48)	100	(52)	
History of syncope					
Yes	163	(72)	62	(28)	<0.001
No	126	(37)	211	(63)	
Other neurological symptoms					
Yes	89	(82)	19	(18)	<0.001
No	200	(44)	254	(56)	
ECG abnormalities					
Yes	35	(67)	17	(33)	0.006
No	204	(47)	227	(53)	
Cardiac enzyme abnormalities					
Yes	34	(49)	36	(51)	0.681
No	150	(46)	177	(54)	
Carboxyhemoglobin (mean% ± SD)	30.4	±10.7	24.8	±9.2	0.029

with other neurological symptoms, 82% (n = 89) of patients were recommended to receive HBOT (P < 0.001).

Chest pain was present in one patient and hypotension in two; however, the ECG was normal in these patients. HBOT was recommended for all three of these patients with other indications for HBOT pregnancy (n = 1); coma (n = 1); cardiac enzyme abnormality (n = 1). ECG data were available in 483 patients. Of these, 11% (n = 52) had abnormal ECG findings including ischaemic changes (ST abnormalities, T negativity, non-ST myocardial infarction, left bundle branch block), atrial fibrillation, extra-systoles, tachycardia, right axis deviation, and prolonged QT. HBOT was recommended for 67% (n = 35) of patients with ECG abnormalities (P = 0.006; Table 2).

There were 21 pregnant patients with CO poisoning, of whom we recommended HBOT for 14 whose average COHb level was 24.1 ± 5.3%. The average COHb level of the seven pregnant patients who were not recommended HBOT was 17.5 ± 10.3%. Of these, five had no history of syncope, neurological symptoms, cardiovascular symptoms, ECG abnormality or cardiac enzyme abnormality. The status of their foetus was reported as normal by obstetric consultants. However, two other pregnant patients had a history of syncope. One of these patients was referred from Konya from where transportation takes two hours to our institution, and the elapsed time between hospital admission and HBOT consultation was eight hours. The other patient was referred from Karabük where transportation takes three hours to our institution and the elapsed time was four hours.

Eight patients had 24 hours of CO exposure and four of them were advised to receive HBOT. One of them was

Table 3
The relationship between clinical characteristics and elapsed time (h) to hyperbaric referral according to whether the patient received hyperbaric oxygen treatment (HBOT/No HBOT)

	HBOT (h)		No HBOT (h)		*P* value
History of syncope	3.8	± 6.8	8.4	± 23.5	0.005
Other neurological	4.8	± 8.3	18.5	± 40.0	<0.001
ECG abnormalities	4.3	± 8.5	7.1	± 11.5	0.305
Pregnancy	1.1	± 0.6	6.0	± 5.9	0.001

pregnant and others had headache, dizziness or weakness. The remaining four patients, who were not advised to receive HBOT, did not have positive symptoms, ECG abnormality or cardiac enzyme abnormality.

We found that patients who were not recommended for HBOT despite a history of syncope, presence of neurologic symptoms at admission or pregnancy had longer delays to HBOT consultation (Table 3).

Discussion

HBOT decisions in patients with CO poisoning can be challenging. In the present study, we found that COHb levels, history of syncope, neurological symptoms, and ECG abnormality were linked to our HBOT decisions. In addition, we found that patients who had been referred after a considerable delay were not accepted for HBOT even if they had a history of syncope, presence of neurologic symptoms at admission or pregnancy.

In one study, HBOT was used in 14 (12.1%) of 116 patients admitted to an ED over a 14-year period.[14] However, 60% of the patients were classified as mild according to a poisoning severity score/clinical score (European Association of Poison Centres and Clinical Toxicologists/International Programme on Chemical Safety). This may explain the low proportion of HBOT recommendations.

Only 19% of all CO poisoning patients presenting to one Taiwanese ED were treated with HBOT in that institution's hyperbaric medicine department.[15] The authors reported that the National Health Insurance of Taiwan did not cover the cost of HBOT and that there was no standard HBOT indication for such cases in Taiwan. This may explain this low referral rate for HBOT despite their institution having a 24/7 HBOT service.

In Jerusalem, 21% of patients with CO poisoning admitted to an ED were referred for HBOT. COHb levels were lower than 25% in 71% of the patients; patients who had convulsions, loss of consciousness or respiratory failure were referred for HBOT.[5] Of 325 paediatric CO poisoning cases admitted to an ED in another study, 81 (24%) received HBOT.[16] The authors classified the patients according to COHb level (10–30% mild, 30–40% moderate, 40–60% severe), with 254 of the 325 patients (78%) classified as mild intoxication unlikely to be referred for HBOT. In another two-year study of paediatric patients, 107 were diagnosed as acute CO poisoning and 55 (51%) received HBOT.[17] This high frequency may be due to the fact that 54 of 74 CO poisoning patients had a COHb > 20%. Similarly, HBOT was recommended for 289 patients (51%) who were referred from 25 different cities in the present study.

According to the UHMS/CDC CO poisoning surveillance programme, the mean COHb level was 23.4% (range 0.1–77.0%) among the patients who received HBOT.[18] In the Jerusalem series, the average COHb level in patients who received HBOT was 22 ± 8% and 16 ± 7% in the group of patients who received conservative treatment ($P > 0.5$),[5] whereas in the present study, the difference in the mean COHb level between patients recommended for HBOT and those who were not was statistically significant ($P = 0.029$).

In two earlier studies, the incidence of syncope was 9% and 23% respectively compared to 40% in our study.[17,19] It is important to realize that our study population differs from many other studies in that only moderate or severe CO poisoning patients were included.

Currently, there is no consensus about the maximum delay to the initiation of HBOT.[18,20] Many of the CO-poisoning-related pathological processes are time dependent and the time window for HBOT in humans remains unknown.[21] Animal studies suggest that lipid peroxidation can be prevented when HBOT is initiated 45 minutes after CO exposure,[22] and that HBOT has a time-dependent protective effect with the highest efficiency being between three and four hours after poisoning.[23] Unfortunately, the efficiency of administering HBOT beyond six hours is not clearly known. Most HBOT practitioners do not recommend HBOT beyond a delay of 24 hours.[20]

The present audit has limitations. We analyzed the phone consultation records of a single HBOT centre; therefore, our results may not be generalizable. Multicentre studies may increase our understanding of how HBOT is used in CO poisoning in real life and help to identify problems. Due to the retrospective design of the study, we rely on only the data available in the records

Another limitation of our study was the lack of information on the discharge status or long-term outcome of patients. Long-term outcome is the most important outcome measure in CO poisoning.[10] We could not follow up the patients after HBOT because our centre covers such a wide area (almost 280,000 km^2) and only a small minority of the patient referrals (10%) came from our own institution. After the end of all HBOT sessions, patients were transported back to their referring hospitals. Lastly, looking at outcome was not the prime purpose of this audit.

Conclusions

In this study, we found that COHb levels, history of syncope, neurological symptoms and ECG abnormalities were related to HBOT decisions. In addition, we found that patients who were referred after a significant delay were not accepted for HBOT despite a history of syncope, presence of neurologic symptoms at admission or pregnancy. CO poisoning remains an important public health problem in our country and the role of HBOT is still not clearly defined. Our study revealed that a significant time was lost before HBOT consultations. Due to this delay, many patients did not receive HBOT despite having criteria defined by the UHMS and ECHM. The reasons for such delay should be investigated in future studies and reliable outcome data obtained.

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Letter to the Editor

Carbon dioxide absorbents for rebreather diving

Firstly I would like to thank SPUMS members for making me a Life Member of SPUMS; I was surprised and greatly honoured by the award.

I also want to confirm and expand on the findings on carbon dioxide absorbents reported by David Harvey et al.[1]

For about 35 years, I was the main player in deciding which absorbent went into Australian Navy and Army diving sets. On several occasions, suppliers of absorbents to the anaesthesia market tried to supply the Australian military market. On no occasion did they provide absorbent that came close to the minimum absorbent capacity required, generally being 30–40% less efficient than diving-grade absorbents. Because I regard lives as being more important than any likely dollar saving, the best absorbent was always selected unless two suppliers provided samples with the same absorbent capacity. On almost every occasion, there was a clear winner and cost was never considered.

I suggest the same argument for the best absorbent should be used by members and their friends who dive using rebreather sets. I make this point because of my findings on a set that was brought to me after the death of its owner. The absorbent was not the type or grain size recommended by the manufacturer of the set and did not resemble any of the diving grade absorbents I knew of. I suspected by its appearance that it was anaesthetic grade absorbent. When I tested the set, the absorbent system failed very quickly so it is likely that carbon dioxide toxicity contributed to his death. The death was not the subject of an inquest and I have no knowledge of how the man obtained the absorbent. Possibly there was someone from an operating theatre staff who unintentionally caused their friend's death by supplying him with 'borrowed absorbent'. I make this point as I would like to discourage members from making a similar error.

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Key words
Rebreathers/closed circuit; rebreathers/semi-closed circuit; risk factors, letters (to the Editor)