Original Article

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The Importance of Hyperbaric Oxygen Therapy In The Management of Carbon Monoxide Poisoning Is Neglected

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Abstract

Objectives: Carbon-monoxide (CO) is a common cause of toxicity with high morbidity and mortality. Hyperbaric oxygen (HBO) therapy or normobaric oxygen (NBO) therapy should be used for acute CO-poisoned patients, though the effects of HBO versus NBO therapy on long-term neurocognitive outcomes remain unclear. The aim of this study is to investigate the rates of HBO therapy in patients admitted to our clinic with CO poisoning.

Material and Methods: This is a retrospective, cross sectional, observational, single centered study that was conducted in a research hospital. Patient files with a diagnosis of CO poisoning based on the ICD10 codes between January 2018 to December 2019 were investigated. Demographic data, median time of stay in emergency department (ED), indication of HBO treatment and if the patient administered HBO were investigated. Carboxyhemoglobin level (COHb) greater than 25% considered as the indication of HBO. The statistical analysis was performed using the Statistical Package for the Social Sciences version 22.0. Mann–Whitney's U test and Student t test were used for the comparison of numerical variables in independent groups. Categorical variables were analyzed using the Pearson chi-squared test. A p-value of <0.05 was considered to be statistically significant.

Results: A total of 152 files were investigated, 80 cases with CO level higher than 5% at admission were included. Number of patients with HBO indication, which considered as COHb level greater than 25%, was 30 and only 8 (26.6%) of them received HBO therapy. Average length of stay at ED was significantly higher at HBO indication positive group (p < .001). There was no difference in terms of COHb level at admission and average length of stay at ED according to HBO treatment status in patients with HBO indication; but COHb level before discharge was significantly lower at the HBO therapy administered group (p .019).

Conclusion: Our study demonstrated that most of the CO poisoned patients with HBO indication were not administered this therapy. Although the current literature provides conflicting data on the effectiveness of HBO therapy at CO poisoning, we considered that HBO should be administered in case of severe CO poisoning to reduce mortality and delayed neurological sequel. However, since CO poisoning is a common condition, there is a need for multicenter, prospective, advanced studies in which patients are followed up for a long time in terms of mortality and morbidity in order to reach consensus and create a management guide.

Key words: Carbon monoxide poisoning; hyperbaric oxygen; neurological sequela; mortality

Özet

Amaç: Karbon-monoksit (CO) yüksek mortalite ve morbiditeye sahip sık karşılaşılan bir toksisitedir. Akut CO zehirlenmesi olan hastalarda hiperbarik oksijen (HBO) tedavisi ve normobarik oksijen (NBO) tedavileri kullanılır, ancak uzun dönem nörokognitif sonlanımda HBO'nun NBO'ya göre etkisi halen belirsizdir. Bu çalışmanın amacı bizim kliniğimize CO zehirlenmesi ile başvuran hastaların HBO tedavisi alma oranlarını incelemektir.

Gereç ve yöntem: Bu bir araştırma hastanesinde yapılan retrospektif, kesitsel, gözlemsel, tek merkezli bir çalışmadır. Ocak 2018 ile Aralık 2019 arasında ICD10 kodlarına göre CO zehirlenmesi tanısı konan hastaların dosyaları incelenmiştir. Demografik veri, acil serviste (AS) ortalama kalış süresi, HBO tedavi endikasyonları ve hastanın HBO alıp almadığı incelenmiştir. Karboksihemoglobin seviyesinin (COHb) %25'ten büyük olması HBO için endikasyon kabul edilmiştir. İstatistiksel analiz SPSS versiyon 22.0 ile yapılmıştır. Bağımsız gruplar arasında numerik değişkenlerin karşılaştırılmasında Mann–Whitney's U testi ve Student t testi kullanılmıştır. Kategorik değişkenler Pearson ki-kare testi ile analiz edilmiştir. P değeri <0.05 istatistiksel açıdan anlamlı kabul edilmiştir.

Bulgular: Toplam 152 dosya incelenmiş CO seviyesi %5'ten büyük olan 80 vaka dahil edilmiştir. HBO endikasyonu olan ki bu COHb seviyesi %25'ten büyük olanlar olarak belirlenmiştir, 30 olup sadece 8 (26,6%) tanesi HBO tedavisi almıştır. Ortama AS'de kalış süresi HBO endikasyonu olan grupta belirgin olarak daha yükseltir (p < .001). HBO endikasyonu olan hastalarda HBO tedavisi alma durumuna göre başvurudaki COHb seviyeleri ve ortalama AS'de kalış süresi açısından fark yoktur; ancak taburculuk öncesi COHb seviyesi HBO tedavisi alan grupta belirgin olarak daha düşüktür (p .019).

Sonuç: Çalışmamız HBO endikasyonu olan CO zehirlenmesi olan hastaların çoğunun bu tedaviyi almadığını göstermiştir. Her ne kadar CO zehirlenmesinde HBO'nun etkinliğiyle ilgili mevcut literatür tutarsız veri sunsa da, biz ciddi CO zehirlenmesi olan hastalarda mortaliteyi ve gecikmiş nörolojik sekeli azaltmak için HBO verilmesi gerektiğini düşünüyoruz. Ancak, CO zehirlenmesi yaygın bir durum olduğundan, bu konuda bir konsensusa ulaşmak ve bir yönetim kılavuzu oluşturmak için hastaların mortalite ve morbidite açısından daha uzun süreli takip edildiği çok-merkezli, prospektif ileri çalışmalara ihtiyaç vardır.

Anahtar kelimeler: Karbon-monoksit zehirlenmesi; Hiperbarik oksijen, nörolojik sekel, mortalite

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Introduction

Carbon-monoxide (CO) is a colorless, odorless and tasteless toxic gas which is produced as a result of the incomplete burning of organic matter; that causes tissue hypoxia particularly in the heart and brain[1]. It is a common cause of toxicity with high morbidity and mortality worldwide that it accounts for 30% of the poisoning cases that end with death in Turkey[2]. Delayed neuropsychological squeal with symptoms such as movement disorders, cognitive impairment or affective disorders is an important morbidity of those patient group[3].

Normobaric oxygen (NBO) and hyperbaric oxygen (HBO) therapies are two basic treatment modalities for CO toxicity. Advantages of treatment with HBO include increased dissolved-oxygen content in blood and accelerated elimination of CO; also its potential benefit is prevention of lipid peroxidation in the brain and preservation of ATP levels[4]. There are many studies in the literature that indicate comparing with CO poisoning patients treated with NBO, HBO treated patients have a lower incidence of neuropsychological squeal[5, 6]. On the other hand HBO has some disadvantages such as risks associated with the transport of the patient to a treatment center, hyperoxic seizures, barotrauma and increased treatment costs[4]. Also there are some conflicting published results about effectiveness of HBO. Juurlink et al. demonstrated that existing randomized trials do not establish whether the administration of HBO to patients with carbon monoxide poisoning reduces the incidence of adverse neurologic outcomes[7].

In the clinical decision process, it is difficult to establish the benefit-risk ratio of HBO because of the reasons mentioned above. The aim of this study is to investigate the rates of hyperbaric oxygen therapy in patients admitted to our clinic with carbon monoxide poisoning.

Material and Methods

This is a retrospective, cross sectional, observational, single centered study that was conducted in a research hospital with the approval of the local Medicine Expertise Training Board. Those patient files with a diagnosis of carbon monoxide poisoning based on the ICD10 (International Statistical Classification of Diseases and Related Health Problems) codes in the hospital data registration system between January 2018 to December 2019 were investigated. Cases whose carboxyhemoglobin (COHb) levels at the time of admission were reached and since smoking habits of the patients were unknown, those with a level of COHb above 10 percent were included in the study. Those cases with a carboxyhemoglobin level less than 10 percent and missing data were excluded.

Demographic data, median time of stay in emergency department (ED), indication of HBO treatment and if the patient administered HBO were investigated. It was not possible to reach the admission complaints of the patients due to the missing data at patient files and records. Therefore carboxyhemoglobin level greater than 25% considered as the indication of HBO.

Statistical Analyzes

The statistical analysis was performed using the Statistical Package for the Social Sciences version 22.0 (SPSS Inc., Chicago, IL, USA). After assessing normal distribution using the Kolmogorov-Smirnov test, all variables were described in terms of mean ± standard deviation or median and interquartile range (IQR) (25–%75). The descriptive analyses were presented using frequencies for the ordinal variables. Mann–Whitney's U test and Student t test were used for the comparison of numerical variables in independent groups. Categorical variables were analyzed using the Pearson chi-squared test. A p-value of <0.05 was considered to be statistically significant.

Results

A total of 152 files were investigated, 80 cases with CO level higher than 5% at admission were included. Forty-eight of them were female and 32 were male, median age of cases was 40.50 (IQR25.25 – 52). Median CO level of whole study group at admission was 20.85 (IQR 13.4 – 29.85) and average length of stay at ED was 363 min (IQR 287 – 544 min). Number of patients with HBO indication, which considered as COHb level greater than 25%, was 30 and only 8 (26.6%) of them received HBO therapy (Table 1).

There was no difference between the patients with or without HBO indication in terms of age, gender and COHb levels before discharge. However, average length of stay at ED was significantly higher at HBO indication positive group ($p < .001$) (Table 2).

We also analyzed the variables according to HBO treatment status in patients with HBO indication. There was no difference in terms of COHb level at admission and average length of stay at ED. However COHb level before discharge was significantly lower at the HBO therapy administered group (p .019) (Table 3).

Discussion

Our study demonstrated that only 26% of patients with COHb levels greater than 25 percent administered HBO

Table 1. Descriptive variables of the study group

Descriptive variables	
Gender*	
Female	48 (60%)
Male	32 (40%)
Age**	40.50 (25.25 – 52)
CO level at admission**	20.85 (13.4 – 29.85)
Average length of stay at ED**	363 min (287 – 544)
Indication for HBO*	
No	50 (62.5%)
Yes	30 (37.5%)
Number of patients received HBO therapy	8 (26.6%)

Abbreviations: CO: carbonmonoxide; ED: emergency department; HBO: hyperbaric oxygen
*number (frequency%)
**median (Inter quartile range 25 – 75)

Table 2. Analyses of the variables according to HBO indication

Descriptive variable	HBO indication negative	HBO indication positive	p value
Gender*			.119
Female	27	21	
Male	23	9	
Age **	38.5 ± 29.6	45.4 ± 36.4	.06
CO level at admission***	14.35 (12.55 – 19.87)	31.2 (27.62 – 34.95)	**< .001**
CO level before discharge***	3.8 (1.7 – 5.3)	3.8 (0.1 – 7.1)	.619
Average length of stay at ED***	342 min (250 – 405)	533 min (341 – 781)	**<.001**

Abbreviations: CO: carbonmonoxide; ED: emergency department; HBO: hyperbaric oxygen
*number (frequency%)
**mean ± 2 Standart deviation
***median (Inter quartile range 25 – 75)

Table 3. Analyses of the variables according to HBO treatment status in patients with HBO indication

Descriptive variable	HBO treatment negative	HBO treatment positive	p value
Gender*			.96
Female	18	3	
Male	5	4	
Age**	45.13 ± 37.46	46.29 ± 35.36	.886
CO level at admission**	32.39 ±6.58	31.77 ± 5.76	.799
CO level before discharge***	4.1 (2.9 – 8.3)	0.1 (0.02 – 1.9)	**.019**
Average length of stay at ED***	523min (326 – 768)	533 min (396 – 1124)	.54

Abbreviations: CO: carbonmonoxide; ED: emergency department; HBO: hyperbaric oxygen
*number (frequency%)
**mean ± 2 Standart deviation
***median (Inter quartile range 25 – 75)

therapy. Hyperbaric oxygen chambers are available at only 20 cities in Turkey and our hospital is at one of them. So, for patients living in other cities it seems more impossible to achieve HBO treatment. Also COHb level is just one of the indications for HBO therapy at CO poisoning so accurate number of patients with HBO indication may be higher. Therefore, even if there is an indication for HBO, it can be estimated that the rate of CO poisoned patients administered HBO is lower than 26% nationwide.

Moderate to severe CO poisoning can cause profound effects on vital organs. Cardiac dysfunctions including arrhythmia, left ventricular systolic dysfunction, and myocardial infarction may be associated with increased mortality [8]. Also survivors of CO poisoning suffer from long-term neurocognitive squeal related to brain injury which is an important cause of morbidity. Those symptoms include impaired memory, cognitive dysfunction, depression, anxiety, and/or vestibular and motor deficits[9]. Although HBO use is recommended for such serious poisonings by the experts in the hyperbaric medicine field, American College of Emergency Physicians acknowledges HBO as a therapeutic option for CO poisoning, but its use is not mandatory[9]. So there were conflicting opinions on this issue.

Most of the studies in the literature recommend administration of HBO in CO patients with neurological deficits, cardiac ischemia, loss of consciousness, metabolic acidosis, and COHb values >25%[10]. Rose et al. demonstrated that hyperbaric oxygen is associated with reduced acute and reduced 1-year mortality[11]. In another study Weaver et al. demonstrated that three hyperbaric-oxygen treatments within a 24-hour period appeared to reduce the risk of cognitive squeal 6 weeks and 12 months after acute CO poisoning[4]. On the other hand at a more recent study Wang et al indicated that HBO therapy significantly reduces the risk of memory impairment compared to NBO, but two sessions of HBO might not be better for memory impairment than one session of HBO[12].

There were also publications on the opposite view. The 2017 ACEP Clinical Policy on CO Poisoning provides Level B recommendations that HBO therapy or high-flow NBO therapy should be used for acute CO-poisoned patients, though the effects of HBO versus NBO therapy on long-term neurocognitive outcomes remain unclear[13]. Even that Huang et al. demonstrated that risk for neurological squeal was higher in patients with CO poisoning who received HBO than in those who did not[14]. Possible contributing factors to this result may be those; firstly patients who had risk for neurologic squeal were more likely to receive HBO and secondly because HBO reduces mortality, the high-risk survivors tended to develop neurologic squeal afterwards[14].

Another variable that affects the effectiveness of HBO treatment is time. In study of Liao et al. multivariable logistic regressions revealed that longer duration from CO exposure to HBO, loss of consciousness, and the presence of multiple victims were independent predictors of delayed neuropsychiatric squeal development in patients with CO poisoning who received HBO[15]. So, studies recommend administration of HBO therapy as early as possible, especially within 4-6 hours after poisoning[16].

Conclusion

Our study demonstrated that most of the CO poisoned patients with HBO indication were not administered this therapy. Although the current literature provides conflicting data on the effectiveness of HBO therapy at CO poisoning, we considered that HBO should be administered in case of severe CO poisoning to reduce mortality and delayed neurological sequel. However, since CO poisoning is a common condition, there is a need for multicenter, prospective, advanced studies in which patients are followed up for a long time in terms of mortality and morbidity in order to reach consensus and create a management guide.

Limitations

Since the study was retrospective, it had many limitations. Firstly, complaint of the patients at admission to ED were not recorded to hospital registry system. Therefore HBO indications other than carboxyhemoglobin level could not be determined. Secondly, we knew the discharge time of the patients who administered HBO, but the time they reached to HBO chamber were unknown; and that makes impossible to calculate the duration from CO exposure to HBO therapy. Also, those patients were not followed up. So it was not possible to evaluate whether there was a difference in term of morbidity in patient who administered and not administered HBO.

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