ELSEVIER

Archives of Medical Research 37 (2006) 991–997

Archives of Medical Research

ORIGINAL ARTICLE

Influences of Hyperbaric Oxygen on Blood Pressure, Heart Rate and Blood Glucose Levels in Patients with Diabetes Mellitus and Hypertension

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Received for publication December 19, 2005; accepted May 11, 2006 (ARCMED-D-05-00517).

Background. We investigated the influences of hyperbaric oxygen (HBO_2) on systolic blood pressure (SBP), diastolic blood pressure (DBP), heart rate (HR) and blood glucose level (BGL).

Methods. Forty one patients with hypertension (HTN), diabetes mellitus (DM), HTN and DM and/or no HTN or DM underwent HBO_2 sessions (15–40 sessions for each patient). SBP, DBP, HR and BGL (for diabetics) were recorded before and after each session.

Results. HBO_2 caused significant elevation in SBP (11%) and DBP (12%) and a decrease in HR (18%) ($p < 0.001$). Patients with DM and HTN showed higher elevation in SBP and DBP. HBO_2 lowered BGL by 23% ($p < 0.001$). When basal BGL was in the range of 120–170 mg/dl, it dropped to <100 mg/dl in 31/60 treatment sessions (52%). When basal BGL was <120 mg/dl it dropped to <70 mg/dl in 8/34 sessions. There was a possibility of lowered BGL when basal BGL was <170 mg/dl and a marked reduction in BGL occurred when basal BGL was <120 mg/dl. HBO_2 caused a marked elevation in SBP and DBP when basal SBP was >140 mmHg. Critical elevation was obtained when SBP was >160 mmHg. The use of beta blockers caused significant elevation of blood pressure while reducing HR.

Conclusions. HBO_2 causes elevation of blood pressure and lowering of HR and BGL, which were augmented in the presence of HTN, DM, or beta blocker. The use of beta blockers for the management of HTN should be avoided during HBO_2 therapy. © 2006 IMSS. Published by Elsevier Inc.

Key Words: Hyperbaric, Heart rate, Glucose, Diabetes, Hypertension, Beta blocker, Oxygen.

Introduction

HBO_2 means breathing pure (100%) oxygen while in a chamber at increased ambient pressure. Treatment is administered using monoplace chambers that accommodate one individual usually in the supine position, or multiplace chambers that accommodate two or more patients. HBO_2 has been shown to be safe with few complications (1). Center for Medicare and Medicaid Services (CMS) following the recommendations of the Undersea and Hyperbaric Medical Society (UHMS) has approved use of HBO_2 for several indications. These include acute carbon monoxide poisoning, decompression sickness, gas embolism, gas gangrene, acute traumatic peripheral ischemia, crush injuries and suturing of severed limbs, progressive necrotizing infections, acute peripheral arterial insufficiency, preservation of compromised skin grafts, chronic refractory osteomyelitis, osteoradionecrosis, soft tissue radionecrosis, cyanide poisoning actinomycosis and diabetic wounds of the lower extremity. Research, however, into the effectiveness of HBO_2 for a number of other conditions is ongoing (2–5).

HBO_2 increases parasympathetic activity and endothelin-1 activity in divers and healthy volunteers (6–8). It increases catecholamines and thromboxane B2 and induces vasoconstriction (10–12). In chronic heart failure, HBO_2 reduces aldosterone secretion and renin secretion rate (13). In rats, HBO_2 elevated SBP and pulse pressure, while mean arterial blood pressure remained unchanged (14,15).

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0188-4409/06 $–see front matter.
doi: 10.1016/j.arcmed.2006.05.009

HBO_2 decreased HR in animals, divers and patients with ischemia of lower extremities (14–17). It elevates left ventricular pressure and contractility in rats (12). Diabetic patients may show fluctuation in BGL while receiving HBO_2. HBO_2 increases glucose utilization in the rat brain and stimulates residual insulin secretion in DM (18–20). These neuronal and hormonal changes observed during HBO_2 make close monitoring of BGL, blood pressure and HR an extremely important task to avoid possible complications. In this study we investigated the effects of HBO_2 on SBP, DBP, HR and BGL in patients with HTN, DM, HTN and DM and in non-diabetic or non-hypertensive patients. Complications were monitored during and after each HBO_2 session.

Patients and Methods

Patients

We studied 41 patients treated with HBO_2 as part of their management for various indications (Table 1). There were 27 males and 14 females; ages ranged from 31 to 86 years (mean: 61 ± 14.6 years). The patients were referred to our Hyperbaric Unit (Life Support Technologies Group), Chronic Wound Treatment and Hyperbaric Medicine Center, The Mount Vernon Hospital, New York, from medical or surgical departments of the hospital and from other health facilities. The patients were divided into four groups for comparison: 1) hypertensive patients; 2) diabetic patients, 3) diabetic and hypertensive patients, and 4) patients who had no HTN or DM. The patients were closely observed for any side effects during the depressurization phase of the treatment and following completion of each treatment.

Table 1. Patients admitted for study

Variables	Number	Percentage
Number of patients	41	
Male	27	66
Female	14	34
Age	Mean: 61 ± 14.6 (31–86)	
Associated diseases		
Hypertension	6	15
Diabetes mellitus	11	29
Hypertension and diabetes	12	29
No hypertension, no diabetes	12	29
Gout	2	5
Renal failure	1	2
Malignancy	8	20
Asthma	1	2
Valve replacement	1	2
Arthritis	1	2
Cerebrovascular accident	1	2
Depression	3	7
Hypothyroidism	2	5
DVD	1	2
Anemia	3	7
Glucoma	1	2
Treatment		
Hypertension: beta blockers	7/17	41
Diabetes mellitus: insulin	16/23	70
Indications for HBO_2		
Chronic osteomyelitis	16	39
Osteoradionecrosis	6	15
Necrotizing fasciitis	1	2
Compromised skin graft	6	15
Chronic ulcer	9	22
Nonhealed wound	4	10

Treatment Protocol

Treatments were administered in a monoplace chamber (Environmental Tectonics Corporation, Southampton, PA) with the subject breathing 100% oxygen. Qualified technicians administered the HBO_2. Specialist physicians in hyperbaric medicine were available during HBO_2 treatment. Treatment protocol was 2.0–2.5 atmosphere pressure (ATA) for 60–90 min, according to the indication. Treatment was given one session per day from Monday to Friday. Compression was started after 15 min bed rest and 2.0–2.5 ATA was reached in 10–15 min. Patients remained in the supine position during each session. Number of treatment sessions was 15 to 30 for each patient. Data from 700 HBO_2 treatment sessions were reviewed for SBP, DBP, HR, and BGL activity and recorded side effects.

Vital Signs and Blood Glucose Level Measurements

Basal supine blood pressure, HR and BGL measurements were made before depressurization and were repeated within 10 min following completion of each HBO_2 treatment session. Blood pressure and HR were measured with use of an electronic monitor (Datascope Corp., Mohwash, NJ). BGL was measured electronically using the finger prick method (Professional Care Lifescan, Milpitas, CA). When basal BGL was <100 mg/dL, the patient was given juice or a sandwich before the session. Vital signs and BGL were measured after 15 min supine rest.

Statistical Analysis

Data were expressed as mean ± standard deviation. A paired and unpaired *t*-test was used to compare means before and after treatment for each patient and for each group. ANOVA test was used to compare means of the four groups. A probability value of <0.05 is statistically significant. An *F* test was used to evaluate the statistical significance of between-group differences. The *F* value is the measurement of distance between individual distributions. As *F* goes up, *p* goes down.

Results

Criteria for Patients

Table 1 shows the criteria for patients enrolled in the study. The most common indication for HBO_2 in our patients was chronic osteomyelitis. Most of the patients had DM and