Hyperbaric Oxygen in the Treatment of Migraine With Aura

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Cephalalgia is one of the most common medical complaints and the search continues for relief. Early treatments for migraine included inhalation of 100% oxygen. It has been theorized that the increased levels of oxygen in the blood act as an alpha-adrenergic agent to alleviate headache pain through vasoconstriction and local metabolic effects. The presence of muscle tenderness during some migraine headaches has also been established. The purpose of this study was to document relief of cephalalgia through use of a visual analog pain scale, algometry, and manual palpation. Female subjects with confirmed migraine were randomly assigned to begin with either the control (100% oxygen, no pressure) or hyperbaric treatment (100% oxygen, pressure). Manual palpation and algometry of 10 sites were done, bilaterally, by a trained specialist. Pain was evaluated with a visual analog scale. Resolution of tenderness and edema following both treatments was observable by manual palpation while algometry showed no differences between the two. Subjective pain was significantly decreased following hyperbaric oxygen treatment but not following the control treatment. Results suggest that hyperbaric oxygen treatment reduces migraine headache pain and that the patient's subjective assessment was the best indicator of relief.

Key words: *hyperbaric oxygen, migraine, algometry, manual palpation*

Abbreviations: NBO_2 normobaric oxygen, HBO_2 hyperbaric oxygen, VAS visual analog scale

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Head pain is one of the most common complaints presenting to physicians in the United States. At any given time, between 5% and 10% of the population are seeking relief from intermittent headache.[1] Of the estimated 10% to 20% of the population that suffer headache pain,[2] 8% are attributed to migraine and more than 90% of headaches are complicated by muscle tension.[3] While representing a small percentage of all types of headaches, migraine headaches are associated with considerable morbidity and may be the most common type of headache pain requiring medical intervention.

Oxygen inhalation, in the past, had been used with some success in aborting migraine headache,[4] but more recently, its use in treating cluster headache attacks has gained support.[5] Inhalation of 100% oxygen constricts cerebral arteries and, thus, opposes the cranial artery dilation shown to be a factor for both headache types.[5-9] Normobaric oxygen (NBO_2) inhalation (100% oxygen delivered at sea level) therapy is now a well-accepted treatment for cluster headache.[9] Hyperbaric oxygen (HBO_2) (100% oxygen delivered at greater than normal atmospheric conditions) produces higher levels of oxygen in the blood than NBO_2, thus producing greater vasoconstriction[10] in headache relief.

Myers and Myers[11] used 100% oxygen under hyperbaric (2.0 atmospheres absolute [ATA] or 33 feet of sea water [fsw]) and normobaric (1.0 ATA or sea level) conditions to treat migraine headache. Only 1 of 10 in the NBO_2 group received significant pain relief while 9 of 10 in the HBO_2 group found relief. Pascual et al[12] used HBO_2 to treat cluster headache sufferers prophylactically. These patients were chronic sufferers who had not responded to pharmacological treatments. Three of four patients improved, suggesting that daily HBO_2 treatments may act as a transient preventive treatment in difficult cases. Fife and Fife[13] have previously demonstrated that HBO_2 therapy abolished the nausea associated with migraine pain after 5 minutes, the pain after 12 minutes, and the photophobia after 16 minutes of treatment. Pain relief was obtained at depths of 2.4 ATA (45 fsw), but also at pressures as low as 1.3 ATA or approximately 10 fsw. In all subjects included in this study, the headache pain had been present for several days and was

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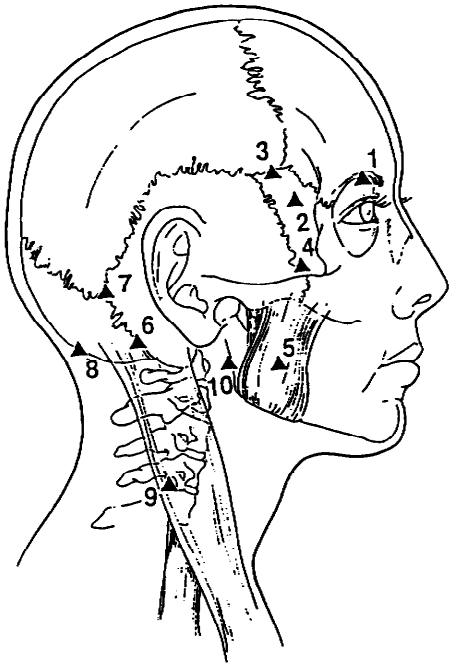
Table 1.—Inclusion and Exclusion Criteria for Study Participants

Inclusion Criteria:
- Nonpregnant, otherwise healthy women between 20 and 65 years of age
- Diagnosis of migraine with aura confirmed by a neurologist at least 18 months prior to study entry
- Stable migraine episodes occurring regularly without an obvious precipitant and having no significant seasonal component

Exclusion Criteria:
- Episodes of migraine headaches which routinely last longer than 4 days or result in objective neurologic deficits
- Episodes whose average occurrence is less than two times per month
- Individuals with migraine headache responsive to standardized preventative or abortive therapy
- Individuals with permanent neurologic deficits or any chronic medical disease process which might increase the risk of hyperbaric therapy

unresponsive to a variety of therapeutic interventions. In the studies cited above, results were reported using only a 10-cm pain scale,[11] as a decrease in frequency of attacks,[12] or the time (in minutes) to disappearance of pain.[13] The purpose of this study was to document any changes that occurred in the resolution of migraine headache pain following oxygen inhalation at normal and hyperbaric pressures using additional objective measures: a visual analog scale (VAS), manual palpation, and algometry.



These 10 bilateral tender points are listed by anatomical landmarks according to Tfelt-Hanson et al[15]: (1) supraorbital foramen; (2) greater wing of the sphenoid; (3) junction of the sutures of the parietal, temporal, frontal, and sphenoid bones; (4) infratemporal crest of the sphenoid; (5) midpoint of the body of the masseter muscle; (6) inferior portion of the occipitomastoid suture; (7) junction of the sutures of the parietal, temporal, and occipital bones; (8) insertion of the linea nuchae approximately 1 cm from midline; (9) transverse processes of the fourth cervical vertebra; and (10) posterior surface of the ascending ramus of the mandible just under the ear.

SUBJECTS AND METHODS

Eight women with a confirmed diagnosis of migraine with aura (mean age 38.8 ± 7.8 years; attack frequency/range = 1 to 10 per month) entered the study. (See Table 1 for entry criteria.) Only subjects with an illness duration of more than 5 years were included. After obtaining informed consent, each subject underwent a history and physical examination and an explanation of HBO_2 therapy by the study physician and were shown a picture of a monoplace hyperbaric chamber. Subjects were randomly assigned to either treatment group "A" or "B." Group A received HBO_2 therapy for their initial treatment followed by the sham treatment with NBO_2; while group B received the sham treatment (NBO_2) first, followed by the HBO_2 treatment. All physicians, personnel, and subjects associated with the study were blinded to the groupings and previous results, except for the individual in charge of administering the treatments. Subjects were asked not to change current medications for migraine pain upon entering the study; however, prescription pain medication was stopped 6 hours prior to treatment in the chamber.

Subjects were instructed to contact the study coordinator when their next migraine headache occurred. They were cautioned to be sure that this was a true migraine with accompanying nausea, vomiting, and photophobia. After receiving the call, treatment was scheduled within 2 hours.

Upon arrival at the Hyperbaric Clinic and before entering the chamber, each subject received a pretreatment assessment that included: (1) subjective pain evaluation using a VAS, (2) a dolorimeter, and (3) manual palpation (Figure). This information was collected immediately prior to and following HBO_2 and NBO_2 treatments. No information about the subjects' medical history was available to the examiner.

The severity of the headache was evaluated using the VAS from 0 (no headache) to 10 (intolerable headache). The horizontal measurement was scored as a linear representation of pain. The visual analog used here has been determined to be more sensitive than the traditional simple descriptive pain scale and the best available method for measuring pain or pain relief.[14]

Manual Palpation.—Pericranial tenderness was evaluated by palpation of 10 tender points, bilaterally.[15] The palpation was carried out with the second and third fingers of each hand while the subject's head was supported on a pillow. Tenderness was assessed according to a 4-point scale: 0 = pain, 1 = mild pain and tenderness, 2 = moderate pain and tenderness, 3 = severe pain and tenderness.

Algometry.—The dolorimeter (Chatillon, Inc) used was a spring-loaded algometer capped with a rubber stopper. It was calibrated in kilograms, and our findings are expressed as kilograms per centimeter squared (kg/cm^2). The bilateral measurements were done on the same tender points as the manual palpation. In using the dolorimeter, the examiner first located the tender point site by digital palpation and placed the dolorimeter on that site. The position of the stopper was

secured by the examiner with one hand, and the pressure on the instrument was increased with the other hand until the subject's pain tolerance was reached.

Hyperbaric Oxygen Treatment.—Using 100% oxygen, subjects were given a standard HBO_2 treatment which included compression over 10 minutes to a depth of 2.4 ATA. The subject remained in the chamber for 20 minutes following the cessation of pain or a duration at pressure not to exceed 60 minutes. The treatment was followed by slow decompression (0.1 ATA per minute). The hyperbaric chamber is pressurized with 100% oxygen which eliminates the need for a hood or mask. However, each subject was required to change into 100% cotton clothing, remove any makeup, and brush any hairspray out of their hair prior to entering the chamber. This was done to minimize potential hazards encountered in a 100% oxygen environment.

Normobaric Oxygen Treatment.—Subjects were placed in the chamber, however, the pressure was changed up and down by no more than 0.1 ATA to give the impression of pressure changes. The pressure adjustments lasted approximately 5 minutes with the final pressure level set at 1.1 ATA. The subject was kept at that pressure for 60 minutes, followed by a simulated decompression of 5 minutes.

During treatments, subjective pain was assessed every 10 minutes using the VAS. Following the treatment and after the subject had been removed from the chamber, assessments of *subjective pain, dolorimetry, and manual palpation were* repeated. The second phase of the study (cross-over) was done 60 to 90 days later, at which time the alternate treatment (HBO_2 or NBO_2) was substituted and the evaluation sequence repeated.

Statistical Analysis.—Scores obtained by palpation of the 10 tender points on the left and right sides of the head were totaled, and the sums of the 20 points were analyzed using a Mann-Whitney test. The scores obtained at the same points with the dolorimeter were analyzed in similar fashion. Because there were more data points (every 10 minutes for up to 2 hours) than subjects for the pain scale, only the differences between the first and final scores from the pain scale (VAS) of the HBO_2 and NBO_2 treatments were analyzed.

RESULTS

The pretreatment versus posttreatment results of manual palpation, dolorimeter assessment, and the VAS are shown in Table 2. There was a significant decrease in the scores obtained from palpation, irrespective of the treatment. This indicates that the severity of responses elicited on palpation by the evaluator diminished significantly whether the subjects received NBO_2 (P=0.02) or HBO_2 (P=0.03).

The dolorimeter was used to obtain an objective measure of pain at the same pressure points as palpation. These results indicate the subjects had a greater pain pressure threshold following both treatment conditions. However, the increased dolorimeter scores following treatment were not significantly different for either the NBO_2 (P=0.90) or HBO_2 (P=0.87) groups.

Conversely, the subjects' responses on the pain scale indicated a significantly greater relief from pain following the HBO_2 treatment (P=0.03) than following the NBO_2 treatment (P=0.99). The starting points for all evaluations were essentially the same as there were no significant differences between the two treatments (NBO_2 or HBO_2) at the beginning (P=0.80) nor at the end (P=0.32) of the treatments.

Table 2.—Pretreatment Versus Posttreatment Results

	Normobaric Oxygen	Hyperbaric Oxygen
Manual palpation		
Pretreatment	25.75 ± 5.03	19.33 ± 4.51
Posttreatment	9.50 ± 2.02	12.33 ± 5.38
P	0.02	0.03
Dolorimeter, kg/cm²		
Pretreatment	34.35 ± 10.92	37.88 ± 6.68
Posttreatment	42.38 ± 11.47	45.07 ± 6.68
P	0.90	0.87
Visual analog scale		
Pretreatment	6.5 ± 0.87	7.9 ± 0.64
Posttreatment	6.3 ± 1.75	3.5 ± 1.34
P	0.99	0.03

Values given as mean ± SE.

COMMENTS

This prospective, randomized, double-blind, cross-over study was conducted to determine the efficacy of HBO_2 therapy in reducing the symptoms accompanying migraine headache and to document the usefulness of manual palpation, algometry, and VAS in measuring those changes. Subjects were restricted to women suffering from migraine with aura as determined by an internist or neurologist.

Tfelt-Hansen et al[15] have described the pericranial muscle tenderness that accompanies migraine attacks; however, changes in the palpatory findings of the clinician did not distinguish between the two treatment conditions (HBO_2 and NBO_2) for resolution of swelling and tenderness. Subjects showed significant improvement in the resolution of the tender points following both the HBO_2 and the NBO_2 treatments, suggesting that normal function was restored through the effect of 100% oxygen alone. This supports earlier findings that have advocated the use of 100% oxygen to treat both migraine and cluster headaches.[5-9] We suspect that the vasoconstrictive effect of 100% oxygen in both the HBO_2 and NBO_2 treatments helped reduce the swelling and tenderness, resulting in the resolution of those symptoms on palpation.

In an effort to make the measurement of the tender points as objective as possible, the dolorimeter was employed, and the same tender points were measured with the dolorimeter as with palpation. There were no significant differences in the pain-pressure threshold of the tender points between the two treatments. While the reasons for these results are unclear, it may be

that for this particular type of pain, the dolorimeter was not sufficiently sensitive to distinguish any differences.

The one measure of pain that appears to be used quite often is the VAS that rates the subject's evaluation of their own pain. A significant difference was found in the subject's pain level following the HBO_2 treatment, while there was no improvement in the pain level following the NBO_2 treatment. In other words, subjects were pain-free following the HBO_2 treatment but not the NBO_2 treatment. In addition, the VAS has been cited as the best available method to measure pain or pain relief[14] and our findings support its use.

Sufficient evidence exists, both with our study and those of others, to warrant further investigation into HBO_2 treatment as a potential therapeutic agent that will help resolve the extensive morbidity associated with migraine headache and that the VAS continues to be a useful tool for evaluation.

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