Hyperbaric Oxygenation as an Adjunct Therapy in Strokes Due to Thrombosis

A Review of 122 Patients

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SUMMARY **Results are reported using hyperbaric oxygenation (HBO) in 122 patients with strokes due to thrombosis, both acute and completed. HBO is used as adjunctive treatment and there appears to be justification for a controlled study to delineate the treatment further. The authors believe it is essential to treat patients with stroke at 1.5 to 2 atmospheres absolute (ATA).**

Stroke, Vol 11, No 3, 1980

FOR THE PATIENT with a completed stroke, a number of treatment programs have been evaluated over the past years in order to reduce the area of infarction and to improve oxygenation of borderline zones between normal and infarcted tissue. These programs have included the use of cerebral vasodilators to improve cerebral blood flow, agents to reduce cerebral metabolism such as barbiturates, medications to reduce cerebral edema such as steroids, and mechanical means to raise the oxygen tension in tissues and increase hemoglobin oxygen saturation in an effort to deliver more oxygen to ischemic or infarcted areas.

The use of hyperbaric oxygen (HBO) in patients with both acute and completed strokes has been reported to be helpful in treatment.[1-3] Hyperbaric oxygen has been demonstrated to be effective in controlling cerebral edema[4] which, in patients with acute stroke, may cause transtentorial herniation, impaired cerebral blood flow and death.[5] Hyperbaric oxygenation is believed, in part, to be effective because plasma may carry substantial amounts of oxygen under hyperbaric conditions. It has been demonstrated that with hyperbaric oxygenation oxygen may be transported with extracellular fluid and lymph and total body water may have a high enough oxygen content possibly to provide oxygen for infarcted and marginally ischemic areas resulting from stroke. End reported in 1939 that hyperbaric oxygenation dramatically reduces red cell agglutination which could improve cerebral blood flow.[7] Holbach, et al.[3, 8] reported that HBO can improve symptoms of ischemia in patients with neurologic deficits persisting for an average of ten weeks after internal carotid occlusion.

In a controlled study using air and oxygen in a hyperbaric chamber, it was found that HBO frequently improves the computerized EEG in the affected area of the brain as well as on the contralateral side, and this improvement parallels clinical improvement.[8] Others have also suggested that HBO could be beneficial in the treatment of cerebrovascular disease.[1, 9]

Because the physician's armamentarium in the treatment of a patient with acute stroke is extremely limited and standard drugs, such as heparin and dexamethasone, have not been highly effective, the main program of therapy generally has been watchful waiting and judicious application of physical therapy.

In an effort to assess the usefulness of hyperbaric oxygenation in patients with acute and chronic completed stroke, a retrospective study was designed to analyze the results of this type of treatment in 122 consecutive patients with acute or chronic completed cerebrovascular accident.

Methods

The study of hyperbaric oxygenation was confined to patients with either clearly demonstrable acute cerebral infarction or patients with completed stroke in the chronic phase. Thirty-four patients were believed to have an acute cerebral infarction and 88 patients were believed to have a completed stroke. Table 1 shows the time after the onset of the stroke to admission to the study for all the patients included. Admission to the study within 4 weeks of the onset of the stroke classified the patient as being in an acute phase. After one month to 10 years following a stroke a patient was considered to have a completed chronic stroke. Not all patients were hospitalized for their stroke or were in hospital for treatment at the time HBO was administered. The majority received treatments as outpatients.

The average age of the patients was 66 with an age range of 44–88. Distribution of the age range is shown in table 2. There were 86 men and 36 women included in the study. The diagnosis of stroke was made on the basis of a sudden onset of an acute neurological defect consisting of either hemiplegia or hemiparesis with and without disturbances in sensory and language function with dysphasia or dysarthria. All patients were given a complete neurological examination and CT scans, EEGs, skull x-rays, and cerebral spinal fluid examinations when indicated. Generally, patients with completed stroke had been given the standard treatments for their disabilities, including physical

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TABLE 1 *Treatment Interval, Onset to HBO*

Time after ictus HBO started	Number of patients	No. patients hospitalised during treatment
to 4 hours	16	13
4 hours to 1 week	4	4
1 week to 2 weeks	4	3
2 weeks to 3 weeks	2	1
3 weeks to 4 weeks	8	3
1 month to 2 months	1	0
2 months to 3 months	3	0
3 months to 5 months	5	0
5 months to 8 months	5	0
8 months to 12 months	10	1
12 months to 18 months	11	1
18 months to 24 months	16	0
3 years to 4 years	15	1
4 years to 10 years	8	0
1 year to 5 years (date unknown)	14	0
Totals	122	27

therapy. Acute treatment was largely supportive with control of fluid and electrolyte balance and control of hypertension until the patient stabilized.

Evaluation of the program of treatment was organized around how soon after the onset of the stroke the patient received hyperbaric oxygenation. Sixteen patients were treated within 4 hours of the onset of their stroke and were started at first on a program of one hour of HBO exposure every 12 hours. As some of these patients clearly improved while in the chamber and regressed when out of the chamber, prolonged exposure of up to 2 hours, or more frequent treatments during each 24 hour period, were tried. Patients who were believed to be not responding to treatment were started on one hour of HBO treatment every 6 hours. Generally, after 10 treatments the frequency of treatments was reduced and the reduction continued as the patient maintained earlier remission of symptoms. The treatment for an acute stroke was reduced to one treatment per week and then to one treatment per month. Patients in the group who had treatment beginning within 4 hours of onset of stroke had 12 to 20 HBO treatments with an average of 16 treatments.

Treatment programs for patients with stroke beginning over 4 hours after onset received one hour of HBO treatment per day at 2 atmospheres absolute (ATA) for the first 10 days. Following this, treatments were given at the rate of one per week for approximately 4 weeks and then once a month for maintenance. All patients, with the exception of 6, were treated in a newer, single-place chamber and were in an atmosphere of compressed oxygen. The pressure in the chamber was increased over periods of 5, 7½, or 15 min, depending on the patients' comments about whether or not there was pain or pressure in their ears. The pressure was reduced in the same way at the end of the treatment. Patients with non-acute completed strokes had 10 to 90 treatments with the majority of patients receiving approximately 10 treatments.

TABLE 2 *Age and Sex Distribution*

	Age					
	40–49	50–59	60–69	70–79	80–89	Total
Men	3	9	34	35	5	86
Women	2	2	13	16	3	36
Total	5	11	47	51	8	122

Assessment of Improvement

Degree of improvement in all patients was assessed by the reported symptoms of cerebral infarction and the signs of neurological dysfunction based on examination by neurologists, physical therapists, nurse technicians, and the attending physician. The opinions of the patient's family about effects of treatment were also used in the evaluation. In the patient with a chronic completed stroke, each patient, in a way, served as his own control since his progress prior to treatment could be compared to progress afterward. For all patients, physical therapy was given when indicated during the period the patient was receiving HBO treatment.

Figure 1 shows the assessment of changes in ambulation obtained from three patient groups, categorized at the time treatment was begun as *bedridden, wheelchair bound* and *walking with aids.* These 3 groups were further subdivided based on the time intervals between the onset of the stroke and beginning of HBO treatment (fig. 2). The following results were obtained using HBO treatment.

Bedridden group (N = 11): one patient improved enough to use a wheelchair, 2 patients improved enough to walk with aids, 3 patients improved sufficiently to walk independently and 5 showed no improvement. *Wheelchair* group (N = 31): 8 patients improved and were able to walk with aids, 14 patients improved enough to walk independently, and 9 showed no improvement. In the group categorized as *walking with aids* (N = 48), 27 patients improved enough to be able to walk independently and 21 showed no improvement. It is of interest that improvement in ambulation was seen in patients who had suffered from stroke 4 to 10 years before.

After treatment, patients frequently reported improvement in vision and hearing and a lessening of symptoms of dysphasia, ataxia, dizziness, depression and agitation. They also reported increased ability in dressing and feeding and said they had fewer problems in bowel and bladder control. Many patients reported a more positive attitude toward life and living.

Sixty-two percent of 79 patients who received HBO treatment 5 months to 10 years after the onset of their stroke reported improvement in quality of life

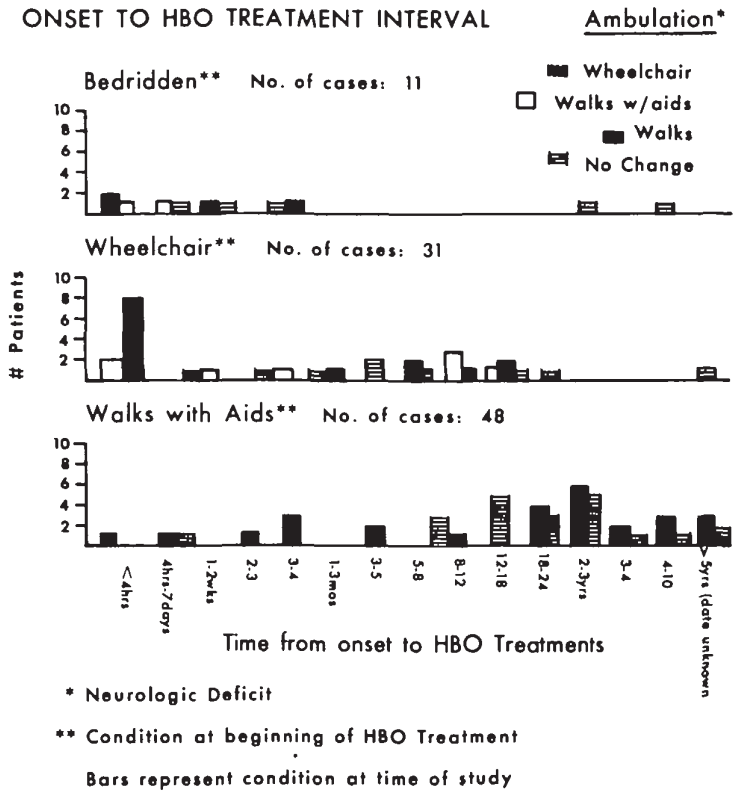

FIGURE 1. *Analysis of response of patients with ambulation problems. Group 1, Bedridden; Group 2, Wheelchair; Group 3, Walks with Aids.*

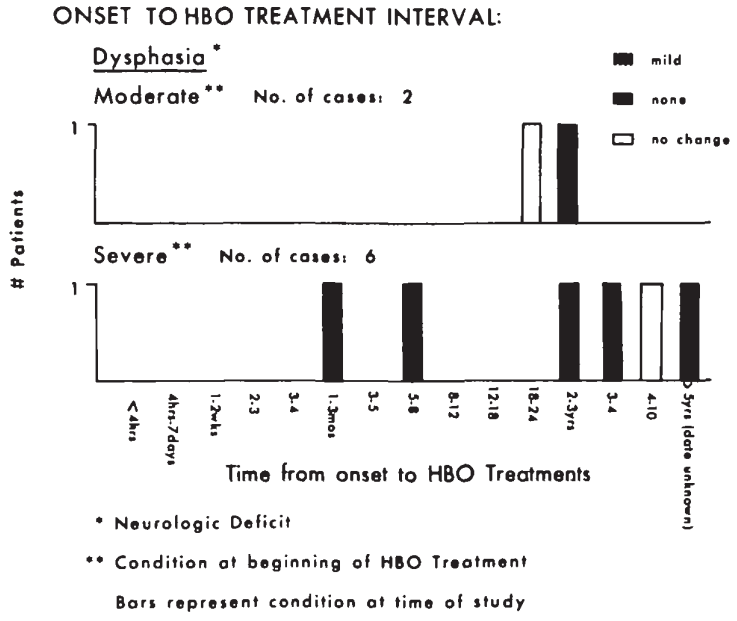

FIGURE 2. *An analysis of patients with dysphasia. Group 1, Moderate; Group 2, Severe at beginning of series.*

behavior, characterized by increased ability to communicate with family members, willingness to participate in social activities, and interest in constructive self-regulatory behavior.

Table 3 shows a comparison of patients with acute stroke treated with HBO within 4 hours of ictus and patients with stroke of similar age, location of cerebral infarction and degree of neurologic impairment treated during the same period in another hospital without HBO. These 2 groups of patients were evaluated by the same neurological consultants. These data show that patients treated with HBO spent fewer days in the hospital (standard treatment 287 days vs HBO treatment 177 days). The 15 patients

TABLE 3 *A Comparative Study of Hospital Stay and Treatment Outcome for 16 Patients Treated Within 4 Hours of Ictus With Standard and HBO Treatment*

Length of hospital stay			
Standard treatment		HBO treatment	
Number of patients	Number of days	Number of patients	Number of days
1	5	4	0
1	8	1	5
1	10	1	9
2	11	1	10
2	14	1	12
1	17	2	15
2	19	2	20
1	24	1	16
2	40	1	26
1	44	1	34
1	47	1	30
1	48		
Total days	287	Total days	177

	Treatment outcome	
	Standard treatment	HBO treatment
Died	2	1
Nursing home	8	0
Home	6	15

treated with HBO, with the exception of one who died during initial hospitalization, returned home following treatment. In the standard treatment group, 2 patients died while hospitalized, 8 were admitted to nursing homes, and 6 returned home. The socio-economic conditions of the patients in both treatment groups were similar.

Discussion

In this study HBO was used as a supplement to the existing therapeutic armamentarium for patients with acute or completed stroke. Using HBO in this way makes difficult an accurate appraisal of results as it cannot be the only form of treatment and a randomized controlled trial was not done.

The analysis of our data does not indicate which patients with an acute or completed stroke will benefit from HBO. It does suggest, however, that a significant number of our patients with completed stroke may benefit from HBO treatment. Clinical experience gained so far suggests that HBO is helpful in the treatment of acute thrombotic stroke. In both acute and completed stroke, pressures of 1.5 to 2 ATA are needed. A minimum of 10 HBO treatments are indicated for patients with acute stroke and 20 treatments for patients with completed stroke.

HBO did not cause significant adverse side effects. Five to six percent of patients developed barotrauma which was usually minor and easily controlled with medication. Myringotomies were required by one percent of the patients. Adverse side effects from HBO can be virtually eliminated by keeping the pressure at 1.5 ATA to 2 ATA, limiting exposure time, and using care during compression and decompression.

By correcting hypoxia, both by increasing oxygen delivery and reducing focal edema in patients with acute stroke, HBO may minimize brain damage and improve chances of recovery of function.

The data presented are based on clinical observation and suggest that a controlled study of HBO in patients with stroke would be desireable.

Acknowledgment

We wish to acknowledge the valuable assistance of Lorraine Steffen in the research and writing of this paper.

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Hyperbaric oxygenation as an adjunct therapy in strokes due to thrombosis. A review of 122 patients.

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Stroke. 1980;11:297-300
doi: 10.1161/01.STR.11.3.297
Stroke is published by the American Heart Association, 7272 Greenville Avenue, Dallas, TX 75231

Print ISSN: 0039-2499. Online ISSN: 1524-4628