

Therapeutic Value of Hyperbaric Oxygen in Peripheral Vascular Disease*

BY

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Introduction

The use of hyperbaric oxygen (HBO) for the treatment of peripheral artery disease and its efficacy has been under controversy since its beneficial effect was first reported by Illingworth¹. The rationale of HBO depends on the increased oxygen availability to the tissue which is in a state of chronic ischemia due to the existing pathology of the blood vessels. Koomen² has also reported success in the majority of 30 subjects treated in his series. However, Slack and co-workers¹¹, on the other hand, reported disappointing results on 26 cases treated with HBO. At our centre a number of cases of peripheral vascular disease were treated with HBO and improvement of varying degrees were observed. Positive improvement shown in 40 cases investigated earlier at our centre¹³ justified further studies.

Method

This study presents another 70 cases treated with HBO. All of them had a history of peripheral vascular disease of more than 4 years duration and showed no lasting benefit with other modes of therapy. In most of these cases lumbar sympathectomy was carried out. The relief of symptoms were temporary lasting for few months.

Baseline record of degree of rest pain, presence of non-healing ulcers, claudication distance on walking, bicycle ergography and skin temperature were noted. Femoral arteriography were done on 25 cases of this group.

The symptom of pain was defined into 4 grades depending on severity.

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- Grade I — Where the pain appears after prolonged exercise only; Claudication distance was measured beyond which the patient was unable to walk without taking rest. Claudication time was elicited by bicycle ergograph against a fixed resistance of 40 watts at 60 rpm, and the time was noted till the patient was unable to continue any further. This test was carried for a maximum period of 15-minutes.
- Grade II — Where pain becomes severe with walking for less than 400 yds. ;
- Grade III — Rest pain is present but is relieved with medication ;
- Grade IV — Rest pain is present and does not get relief with medication. Mean body surface temperature (MBT_R) was calculated from Ramanathan's formula². Temperature of the dorsum of affected foot was calculated by averaging

RESULTS

TABLE-I.
Improvement of pain-severity with HBO Therapy

Before therapy		After HBO Therapy	
Grade of pain	Number of subjects	Grade of pain	Number of subjects
Gd. IV	17	Gd. IV	1
		Gd. III	4
		Gd. II	8
		Gd. I	4
Gd. III	44	Gd. III	4
		Gd. II	18
		Gd. I	22
Gd. II	9	Gd. II	2
		Gd. I	7

the temperature from three fixed anatomical positions and the temperature gradient was calculated by noting the difference between MBTr and the average foot temperature. A reduction in temperature gradient was taken as an improvement of local condition.

The HBO treatment schedule consists of 90 minutes exposures of HBO at 2.5 ATA in a hyperbaric chamber once every day for 36 exposures. This has been found to be safe and effective by Wadhawan and co-workers¹³. After completion of 36 exposures the patients were reviewed after 2 months based on the measurement of same parameters. They were again reviewed 12 months later to determine

whether the improvements, if any, are maintained. Two cases have been reviewed 2 years after completion of HBO therapy.

Results :

Most of the patients suffering from Gd. III and Gd. IV pain showed marked improvement after therapy as may be seen from Table-I. 52 cases got relief from rest pain out of 61 cases. It was commonly observed that relief started to be noticeable after 10 days of treatment.

21 patients of this series had non-healing ulcers, four of them were showing signs of impending gangrene and 2 developed

TABLE II

Table showing improvement of Claudication distance after HBO Therapy.

Before therapy		Distance after therapy (furlong)									
Claud. dist. (fur)	No. of Subjects	0- $\frac{1}{2}$	$\frac{1}{2}$ -1	1-2	2-4	4-6	6-8	8-12	12-16	>16	
0- $\frac{1}{2}$	14	3	2	6	2	1	-	-	-	-	Number of Subjects
$\frac{1}{2}$ -1	12	-	1	3	6	1	-	-	-	-	
1-2	21	-	-	1	12	1	4	-	1	2	
2-4	15	-	-	-	1	5	4	1	3	1	
4-6	1	-	-	-	-	-	-	-	1	-	
	2	-	-	-	-	-	-	1	-	-	

Result contd.

moist gangrene. HBO therapy was administered along with routine local dressings. Ulcers healed up completely in 14 cases on completion of therapy and 7 patients showed improvement to the extent of 60 to 80% which subsequently healed. 2 cases of gangrenous toes were disarticulated and healthy granulation tissue formed while the HBO therapy was continued. The healing was found to be complete during subsequent review.

Table II shows the improvement in claudication distance after therapy, 59 of

the 65 subjects showed improvement, of which 10 patients could walk for more than 1 mile. 5 subjects were not tested, 3 of them were amputees and 2 could not walk because of gangrenous toe,

Results of observation on claudication time are shown in Table III. Most of the subjects showed improvement. However, 4 patients showed a reduction in claudication time.

Improvement in foot temperature as measured from temperature gradient is shown in Table IV, 7 subjects did not show any improvement.

TABLE III

Table showing the changes in Claudication time after HBO,

Before therapy		Time to severe pain after therapy (minutes)						
Time to pain (min)	No. of subjects	0-1	1-3	4-6	7-9	10-12	13-15	15
0-1	2	2	-	-	-	-	-	-
1-3	16	1	5	2	2	1	5	-
4-6	13	-	-	-	3	4	6	-
7-9	2	-	-	-	-	-	2	-
10-12	7	-	-	-	1	1	5	-
13-15	21	-	-	-	-	1	1	19

Number of subjects

TABLE IV

Table showing the improvement in temperature gradient HBO therapy

Improvement by °C	Number of Subjects
Less than 0.5	21
0.5 - 1	17
1.0 - 1.5	10
1.5 - 2.0	4
More than 2.0	11
No significant improvement	7

Femoral Arteriography was performed to demonstrate any increase in regional circulation. Some are shown in Fig. 1 to Fig. 10. Radiological improvement in a number of cases was appreciable and could be correlated with clinical improvement. Four cases did not show radiological improvement, in spite of clinical improvement observed in 3 of them.

Discussion :

The availability of increased oxygen content in blood as well as increased oxygen tension in the tissues are the basic points on which the rationale of HBO therapy depends. These two factors overcome the arterial insufficiency in the distal limb with existing vascular pathology thus relieving the state of chronic ischaemia. However, the major opponents of this view expressed their doubt about any increase in oxygen availability to the tissue. Bird and Telfer² have shown that in-

creased oxygen content under HBO is usually associated with a reduced blood flow in the limb in a normal subject. Thus, they argued, that an observed 18% increase in blood oxygen content at 2 ATA and the associated reduction in flow by 18.9% cancel each other. Reduction in blood flow in different organs has been found to be common in most of the normal tissues and is considered to be a part of homeostatic response. Autoregulation, though common in normal tissues, is unlikely to be present in pathological tissues, a finding which has also been observed during neurosurgical research by Holbach⁴ with cortical blood flow. Moreover, the reduction in blood flow is not the only factor to be considered and the increase in oxygen tension in the tissues has a vital role to play. Oxygen transfer to the cells away from capillaries depends on the tension gradient and the increase in tension under HBO greatly facilitates oxygen transfer. That the



Figure 1 compares the vascularity around knee joint before HBO therapy in a subject with that after HBO therapy in Figure 2. The increase in collateral circulation and the opening of the lower part of popliteal artery can be seen in Fig 2. Clinical improvement noted in this case was appreciable.



Fig. 3 compares the vascularity in the leg, ankle and foot in a subject with that after HBO therapy in Fig. 4.

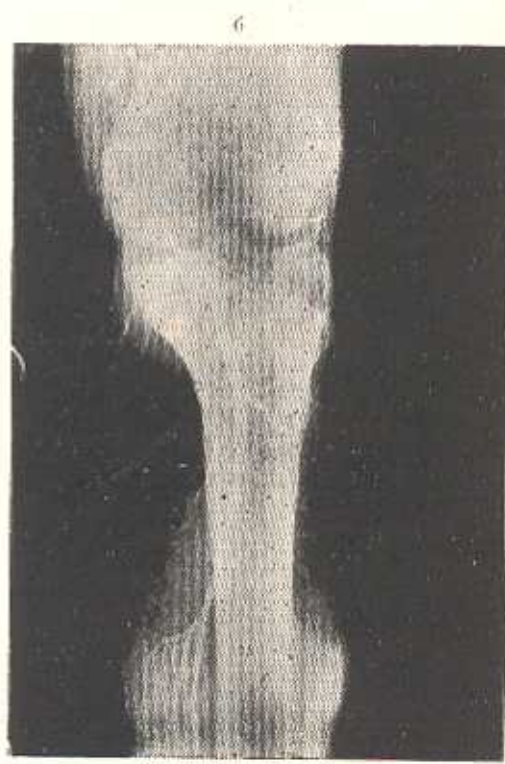


Fig. 5 compares the vascularity around knee and upper part of leg in one patient before HBO therapy with that after HBO therapy in Fig. 6. Appreciable clinical improvement has been noted.



Fig. 7 compares the vascularity around ankle before HBO therapy with that after HBO therapy in Fig. 8.

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HBO

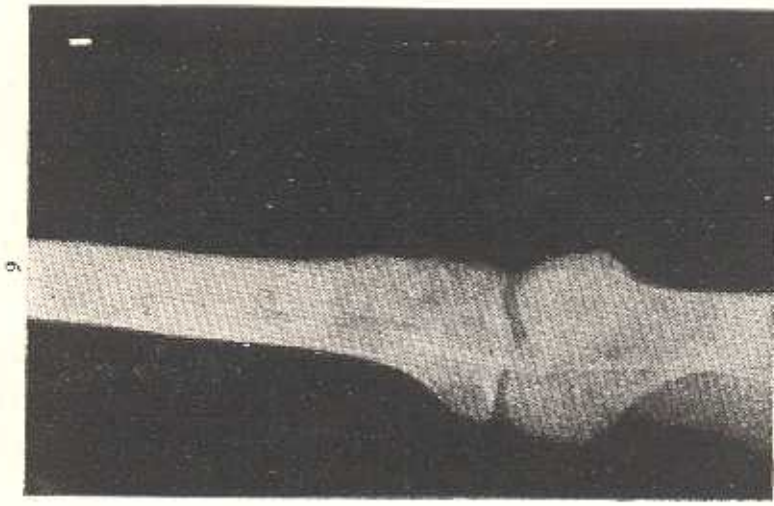
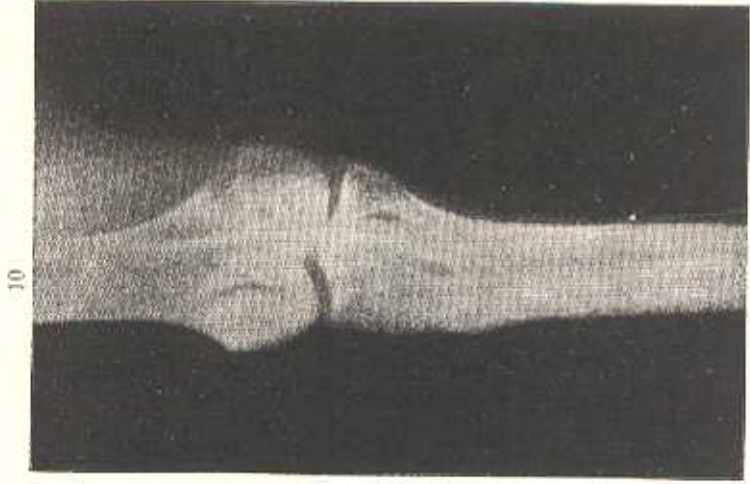


Fig. 9 compares the vascularity around knee joint and upper part of leg in a patient before HBO therapy with that after HBO therapy in Fig. 10.

tissue oxygen shows an immediate rise in the limb muscles has been observed by Ackerman¹ with the help of polarographic electrodes. The rise in oxygen tension has not only been found in muscular tissue but similar finding has also been reported by Jacob⁶ where the cognitive functioning of senile persons was observed to have improved with HBO therapy by likely removal of chronic oxygen deprivation in the cortical tissues.

Boerema³ has expressed an opinion that HBO has no part to play in recanalisation, development of collateral circulation and restoration of blood supply to any appreciable degree in chronic cases like TAO and, therefore, should not provide any improvement in claudication. However, a contrary opinion has been expressed by Schribman,¹⁰ who observed improvement in his group of cases. In a large majority of our cases the improvement in claudication distance and increase in claudication time for an appreciable period and its sustained effects after the discontinuation of therapy are in agreement with the observation of Schribman¹⁰. This suggests the possibility of improvement in circulation. The improvement in peripheral skin temperature also favours this view.

The positive role of hyperbaric oxygen therapy in superficial lesions in chronically ischaemic limbs has been established beyond doubt by the improvement observed in almost all cases of non-healing ulcers and incipient gangrene. Kidokoro⁷ has also reported similar result in cases with ulcer. Inference of improved blood

supply can be made in these cases as these improvements are sustained much beyond the actual period of exposures.

Improvement in rest pain has been observed in majority of our cases. It may be due to the direct effect of HBO in reducing anoxic neuritis as observed by Boerema³. The theory of anoxic neuritis as the cause of rest pain can also be corroborated in our group of cases where daily injections of Neurobion Thiamine hydrochloride (33 mg.), Pyridoxine hydrochloride (33 mg.), Cyanocobalamine (333 Mgm.) for 7 to 10 days were found to be effective in patient prior to HBO therapy. However, the improvement was not sustained and the effects wore off after discontinuation of injections, as the basic condition of chronic tissue anoxia was not altered. On the other hand, a course of HBO was found to have a sustained effect in reduction of rest pain for long period and thus an improvement of underlying pathology of chronic hypoxic state by improved circulation can be deduced.

Studies on femoral arteriography has helped to demonstrate actual increase in collateral circulation and recanalisation in some of our cases after HBO therapy. However, a few cases did not show any radiological improvement though there was improvement in clinical condition. It may be argued that the radiological improvement can only be detected if the newly developed blood vessels are bigger than certain minimum size; the smaller vessels specially capillaries cannot be demonstrated. For this reason we have started taking muscle biopsy from calf muscle of the affected limb which may