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PREPARED BY:

TRANSLATION DIVISION
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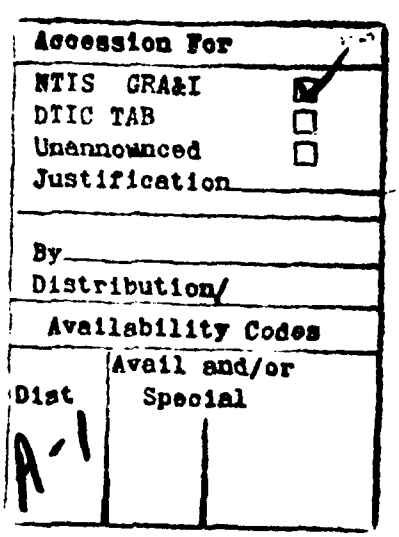

POSTOPERATIVE HYPERBARIC OXYGEN TREATMENT OF PERIPHERAL NERVE DAMAGE

BY: Zhao Dewei, Cui Zhenjiang, Sun Yajuan, Liu Qijia, Wang Yonglin and Zhang Lun of the Qiqihaer Railway Central Hospital Orthopedic Section.

ABSTRACT

This article reports on the results of 114 cases of surgical repair of peripheral nerve damage. Of these, 54 cases involving 65 nerves were given hyperbaric oxygen treatments following surgery. This article uses the other 60 cases as a control group, to explore the results of hyperbaric oxygen treatments for peripheral nerve damage. The excellent recovery rate for the hyperbaric oxygen treatment group was 89.2 percent and for the control group it was 73.2 percent ($P < 0.05$). In observing the recovery of different treatment methods, the average excellent recovery rate for the hyperbaric oxygen was higher than that of the control group, and the nerve transplant group excellent recovery rate was raised even higher to 24.9 percent ($P < 0.05$). In the results of the observation during the different types of recovery, in cases of emergency recovery, the two group treatment results were about the same. As time was extended, the excellent recovery rate of the hyperbaric oxygen treatment group tended to gradually increase over that of the control group.

KEY WORDS: Peripheral nerve, hyperbaric oxygen, nerve matching, nerve transplant, nerve neurolysis

Between July of 1980 and October of 1989, we used microscopic surgery to repair peripheral nerve damage in 173 cases involving 201 nerves (including surgery cases in other hospitals). Of the 114 cases where there were follow-up visits, 54 cases, involving 65 nerves, were given supplemental hyperbaric oxygen treatments. In order to explore the treatment effectiveness of hyperbaric oxygen on post-operative peripheral nerve repair, we are herein providing a comparative analysis of those cases which received hyperbaric oxygen treatments with those cases which did not.

CLINICAL DATA

1. General Data: Of the 114 cases, 89 were males, and 25 were females. The ages of the patients ranged from seven to 54 years old.

2. Causes of injury: Sixty four cases were punctures, 15 were contusions, 12 were lacerations, nine were abrasions, six were gunshot wounds and eight were due to medical causes. In 72 cases there was accompanying comprehensive damage concomitant to blood vessels, flesh and

bone damage. In 42 cases there was only nerve damage.

3. Types of nerves: Of the 114 cases and 136 nerves, six cases involved the brachial plexus, 49 cases involved the ulnar nerves, 41 cases involved the median nerve, 32 cases involved the radial nerves, seven cases involved fibular nerves and one case involved femoral nerves. Follow up visits ranged from after five months to eight years.

THERAPEUTIC METHODS

1. (1). Nerve transplants. There were 54 old damaged nerves with two or more centimeters missing. There were six newly damaged nerves with sections missing. For all of these cases we used femoral or intestinal nerves for transplanting. The number of sections ranged from two to five and the length ranged from three to 20 centimeters. We used 6-0 to 8-0 sheath or external membrane suturing. (2). Nerve connection surgery. There were 44 nerves which were reconnected during emergency treatment and seven previously damaged nerves which were reconnected with exploratory surgery. Fifteen nerve sheaths were sutured and 36 external membranes. (3). Nerve loosening surgery. There were 25 nerves damaged from pinching or were adhered together. We used microscopic surgery to loosen the external sheath and separate the bundles.

2. HBO therapy. There were 54 cases and 65 nerves which received HBO therapy from one to seven days following surgery. We used the HWY-75 model individual hyperbaric oxygen chamber. At ZATA conditions and a steady pressure for 90 minutes once a day for ten days comprised a single treatment. Generally there were from two to three treatments. In two cases there was severe ringing in the ears, and the treatments were stopped. Caution should be used in applying this treatment to patients with serious heart disease, tuberculosis and ear drum ailments.

OBSERVATION OF THE RESULTS OF THE TREATMENTS

The 114 cases were divided up into the HBO group and the control group. Using the six levels method for senses and movement, they were divided into outstanding, excellent, satisfactory and poor. Outstanding was M_4 or better and S_4 or S_3. Excellent was M_3 and S_3. Satisfactory was M_2 and S_2. Poor was M_1 and S_1 or worse.

In the 65 nerves in the HBO treatment group, 89.2 percent were outstanding or excellent, while this was 73.2 percent for the 71 nerves in the control group (see table one). There is a markedly significant difference between the two groups ($P < 0.05$). Observation of the results of the different types of reconstructive surgery showed that the outstanding or excellent recovery rates of the HBO rates were always higher than that of the control group (see table two). In nerve transplants, the HBO treatment increased the outstanding or excellent recovery rate by 24.9 percent over that of the control group, with a significant difference between the two ($P < 0.05$). In observing the

results of different repair times, the results of the cases in the two groups were about the same for emergency repair. As the repair time grew longer, the outstanding and excellent recovery percentage of the HBO group gradually improved over those of the control group (see table three). Even so, with peripheral nerve damage, there should be surgical repair as quickly as possible.

神经	(1) HBO 治疗组						(2) 对照组					
	3 条数	4 优	5 良	6 可	7 差	8 优良率%	3 条数	4 优	5 良	6 可	7 差	8 优良率%
9 臂丛	2		1	1		50.0	4	1	1	1	1	50.0
10 尺	24	10	12	1	1	91.7	25	9	10	4	2	76.9
11 正中	20	9	9	2		90.0	21	8	7	4	2	71.4
12 桡	15	10	4		1	93.3	17	9	5	2	1	82.4
13 腓总	4	1	2	1	0	75.0	3	0	1	0	2	33.3
14 股	0	0	0	0	0		1	0	1	0	0	100.0
15 合计	65	30	28	5	2	89.2*	71	27	25	11	8	73.2*

TABLE ONE : OBSERVED RESULTS OF POST OPERATIVE HBO TREATMENTS

1. HBO TREATMENT GROUP. 2. CONTROL GROUP. 4. Number. 4. Outstanding. 5. Excellent. 6. Satisfactory. 7. Poor. 8. Percentage outstanding or excellent. 9. Brachial plexus. 10. Ulnar nerve. 11. Median nerve. 12. Radial nerve. 13. Fibular nerve. 14. Femoral nerve. * Comparison of the two groups $P < 0.05$.

1 修复方法	2 HBO 治疗组						3 对照组					
	4 条数	5 优	6 良	7 可	8 差	9 优良率%	4 条数	5 优	6 良	7 可	8 差	9 优良率%
10 神经移植	29	10	15	3	1	86.2*	31	9	10	7	5	61.3*
11 直接吻合	24	12	10	1	1	91.7	27	12	10	3	2	81.5
12 神经松解	12	8	3	1	0	91.7	13	6	5	1	1	84.6

TABLE TWO: EFFECTS OF HBO TREATMENT ON DIFFERENT REPAIR METHODS

1. METHOD OF REPAIR. 2. HBO TREATMENT GROUP. 3. CONTROL GROUP. 4. Number. 5. Outstanding. 6. Excellent. 7. Satisfactory. 8. Poor. 9. Percentage outstanding or excellent. 10. Nerve transplant. 11. Direct reconnection. 12. Nerve loosening. * Comparison of two groups is $P < 0.05$.

1 修复时间	2 HBO 治疗组						3 对照组					
	4 条数	5 优	6 良	7 可	8 差	9 优良率%	4 条数	5 优	6 良	7 可	8 差	9 优良率%
10 急诊修复	18	12	5	1		96.2	34	16	14	1	3	88.2
11 1~3个月	25	9	13	2	1	89.0*	22	8	6	5	3	63.6*
12 3~12个月	18	7	9	2		88.0*	13	3	4	4	2	53.8*
13 12个月以上	4	2	1	0	1	75.0	2	0	1	1	0	50.0

TABLE THREE: EFFECTS OF HBO TREATMENT OVER DIFFERENT REPAIR TIMES

1. REPAIR TIME. 2. HBO TREATMENT GROUP. 3. CONTROL GROUP. 4. Number of nerves. 5. Outstanding. 6. Excellent. 7. Satisfactory. 8. Poor. 9. Percentage outstanding or excellent. 10. Emergency repair. 11. One to three months. 12. Three to twelve months. 13. Over twelve months. * Comparison of two groups is $P < 0.05$.

DISCUSSION

1. There have been certain results in experimental research in HBO treatment of spinal injuries and in its clinical use.[1,2]. The principle is to increase the tensile force of the blood oxygen, increasing the PO_2 and the oxygen dispersion so the tissue and nerve cells can obtain sufficient oxygen, thus attaining the treatment objective of improving or correcting oxygen deficiency state. The axons of the peripheral nerves do not have nucleoproteozomes, but rely on nucleoglucoproteozomes to reproduce. HBO treatment of peripheral nerve damage also increases the oxygen utilization rate of the nerve cells, promoting the smooth progress of oxygen metabolism, producing sufficient ATP to help the synthesis of cellular protein, and thus promoting accelerated axon reproduction. Some people have experimentally cut the sciatic nerve of animals and then immediately given HBO treatments, resulting in axone regeneration rate of as much as 75 to 100 percent and with a regeneration speed faster than than of conventional treatment[3]. The observed results in this group of cases was that the HBO treated group had a higher percentage of outstanding and excellent recover than the control group which did not receive HBO treatment ($P < 0.05$). This illustrates that the use of microscopic techniques for repairs following damage to peripheral nerves to allow for better conditions for regeneration, the additional supplemental use of HBO treatments acts to a certain degree to aid in the recovery of nerve functions.

2. HBO treatment does not only promote axon regeneration, but also has the following effects. (1), it increases the oxygen utilization rate of the sheath of Schwann cells, promoting the reduction of inflammatory edema, thus causing the sheath of Schwann cells to form Bunger's strips, aiding in the passage of the axons. (2). In the free nerve transplant repair of damaged nerve, blood transport is very important. Because the transplanted nerve on one hand relies on the tissues of the severed ends for its blood supply, but even more important is that it relies on the capillaries of the surrounding soft tissue to extend into it. HBO

treatment can both increase the blood circulation in nerve transplants and cause the capillary network of the surround soft tissue to quickly establish lateral branch circulation with the transplanted nerve to ensure its blood supply. (3), After surgical repair of damaged nerves, there is still diminished or lost functions of sense, mobility and sympathetic nervous functions for a relatively long time, which causes a localized reduction in blood transport and a reduced oxygen utilization rate and atrophy of tissues of affected organs. HBO therapy can increase the oxygen utilization rate of the tissues which have lost nerve coordination and increase localized blood circulation, improving the conditions for the regeneration of nerve fibers and for the affected organs to recover nerve ending functions. Of the nerve transplant cases in these nerve damage groups, the HBO therapy group function recovery was superior than that of the control group ($P < 0.05$). We can see from this that when there is serious nerve damage, the effects of HBO therapy is only obvious when applied following surgery.

3. Following nerve damage, effective surgical repair methods are of vital importance. The direct rejoining of nerves with tension, poor matching up of sensory and motor nerve bundles when suturing between bundles, and incomplete loosening or separation of pinched or adhered nerves can affect recovery. Even if HBO therapy is used, it will not be with good results. Both of these groups included cases where nerve function recovery was unsatisfactory. This was not only related to the location and degree of damage and time between injury and repair, there were also problems in the quality of the reconstructive surgery[4]. Therefore, it is only when damaged nerves are repaired through microscopic surgery by a competent surgeon that HBO therapy can improve the results.

Following surgical repair of peripheral nerve damage, supplemental HBO therapy acts to promote the recovery of functions, especially in cases of severe nerve damage and nerve transplants.

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