

Topical Oxygen
Promotes
Healing of Leg Ulcers

Reprinted From
Medical Times - December 1976

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The authors report on their own experiences—and that of other clinicians—in the use of oxygen for the treatment of skin lesions and leg ulcers. Their studies suggest that this modality might be equally beneficial in postop healing and skin grafting.

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► The use of oxygen for the treatment of skin lesions is not new—it has been applied in high and low pressures, in sophisticated walk-in chambers,¹⁻² or in individual tanks,³⁻⁴ through simple funnels,⁵ and via plastic bags. The time of treatment has varied from several hours^{6,7} to 20 minutes.⁸

Our method consists of applying oxygen by means of a plastic bag⁹ over the ulcerated leg. We apply the treatment twice a day for 20

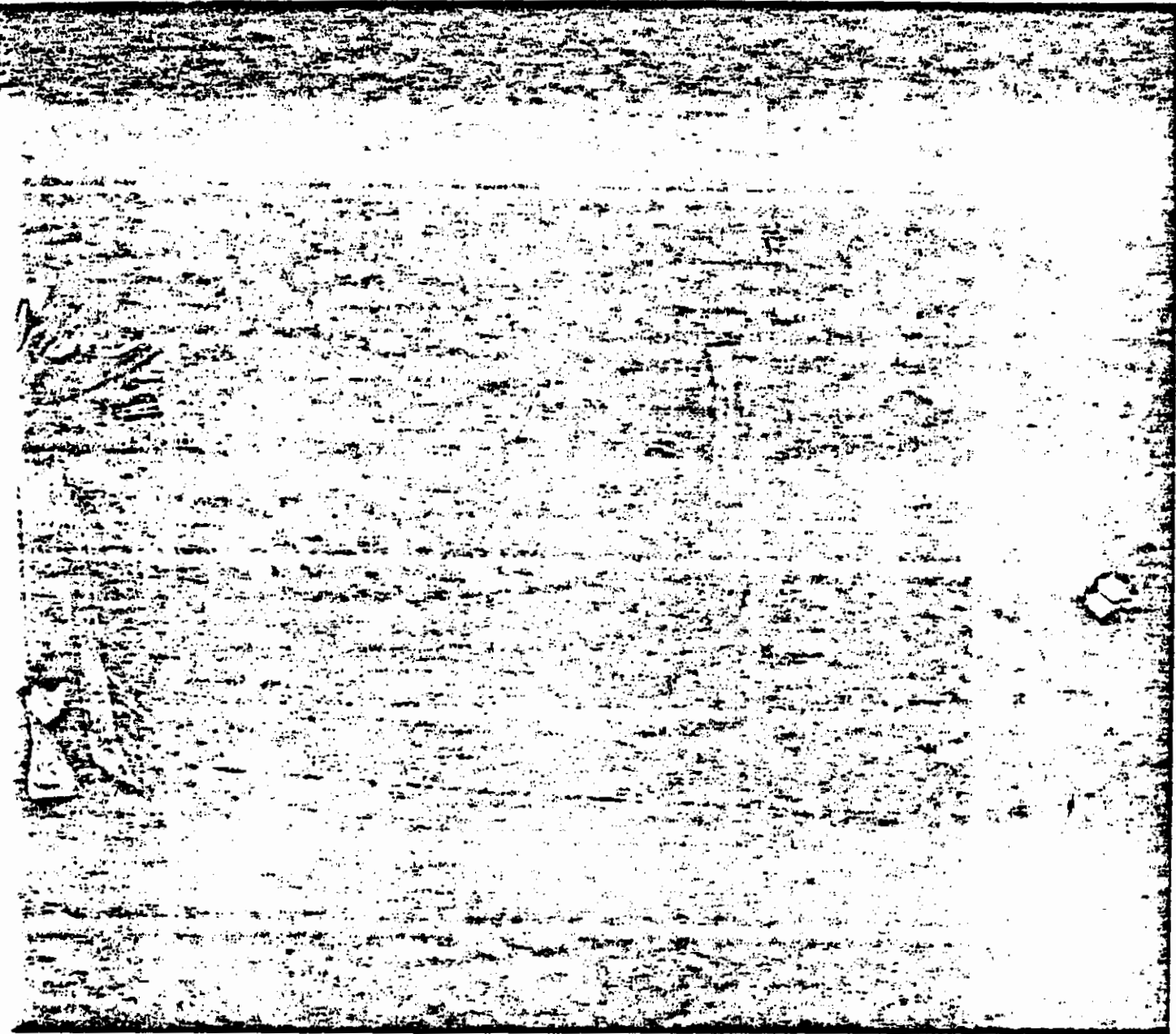
minutes, with pressure in the bag from 0-5 mm of Mercury. Saline solution dressings are applied between treatments to keep the edges of the ulcer from drying.

The oxygen flow is usually 3.4 liters per minute to maintain 0-5 mm of Mercury pressure of oxygen in the bag, which is of transparent nylon-plastic material. It is placed over the extremity with a tourniquet of one inch webbing looped twice then closed with the attached velcro strap.

We published the results of two years experience with this method of treatment in 1966.⁹ The best outcomes then were obtained in patients with stasis ulcerations and venous insufficiency. Over the ensuing years, as our experiences increased and the method grew in popularity, we were asked many questions about the amount of oxygen absorbed and its saturation in the granulation tissue. We also were asked other questions about how much oxygen pressure should be used in the bag for the best results.

• We know that oxygen absorbed in the lungs is carried away to all parts of the body by oxyhemoglobin with about 19.7 ml of oxygen in 100 ml of blood, and 0.3 ml of oxygen in 100 ml of plasma. The oxygen carried by plasma is immediately available to the cells, and life could be sustained even without hemoglobin if sufficient saturation of plasma takes place.⁹

⁹Supplied by Stenobeg Research Co., 1482 Lochridge
Bloomfield Hills, Michigan 48013



In the Bag—A plastic bag covers each ulcerated leg. Oxygen is applied twice a day for 20 minutes, with pressure in each bag from 0 to 5 mm of Mercury. Saline solution is used between the oxygen treatments.

Oxygen in Plasma

Since the amount of oxygen in the plasma is so vital and no doubt plays an integral part in the healing of ulcers, we measured PO_2 in granulation tissue of the ulcers. After thorough investigation of the different ways to measure PO_2 , a polarographic method was selected with the employment of a differential oxygen analyzer.* The PO_2 was measured on the surface of the ulcers and also at a depth of 1 mm with the use of different gases under different pressures.

PO_2 measurements in tissue are quite difficult to do, because the tissue is not of an homogenous material but consists of different density components with different rates of oxygen absorption and consumption.

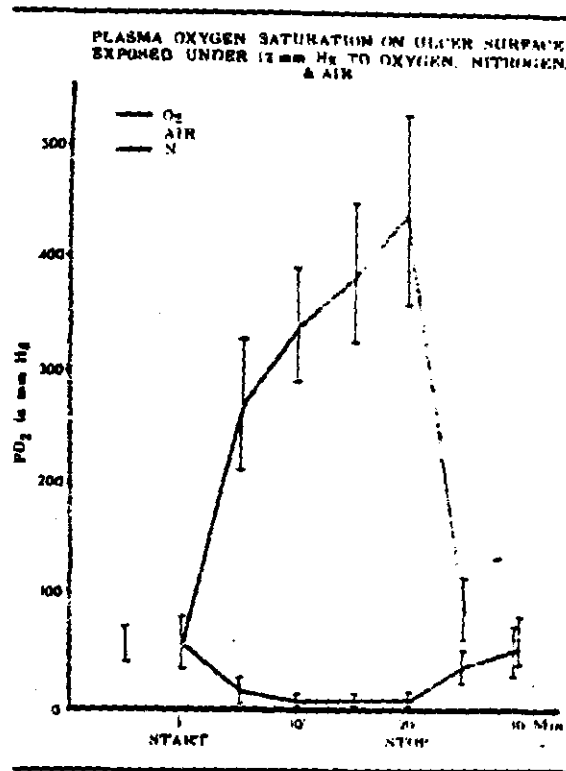
Another problem stems from the fact that despite the very small size of an electrode, its insertion into the tissue causes damage by local ischemia or hemorrhage, and this produces inconsistent values. The results of our studies are presented in Graph 1.

When oxygen was used, the values of PO_2 gradually increased from the initial value of 50 mm of Mercury to an average of 450 mm of Mercury, and dropped to the original value

About the Authors—Dr. Olejniczak was born in Detroit, but was educated in Poland. He received his M. D. from Jagiellonian University, Krakow, in 1950, after serving in the U.S. Army from 1941-1945 in the South Pacific. He did all of his postgraduate work in the U.S. A., at University Hospital, Ann Arbor, Cook County Graduate School of Medicine in Chicago, and at UCLA. He was Board Certified in his specialty in 1963. He has held his present post as Clinical Director of Physical Medicine and Rehabilitation at Wayne County General Hospital since July 1955.

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*International Biophysics Corporation, Irvine, California

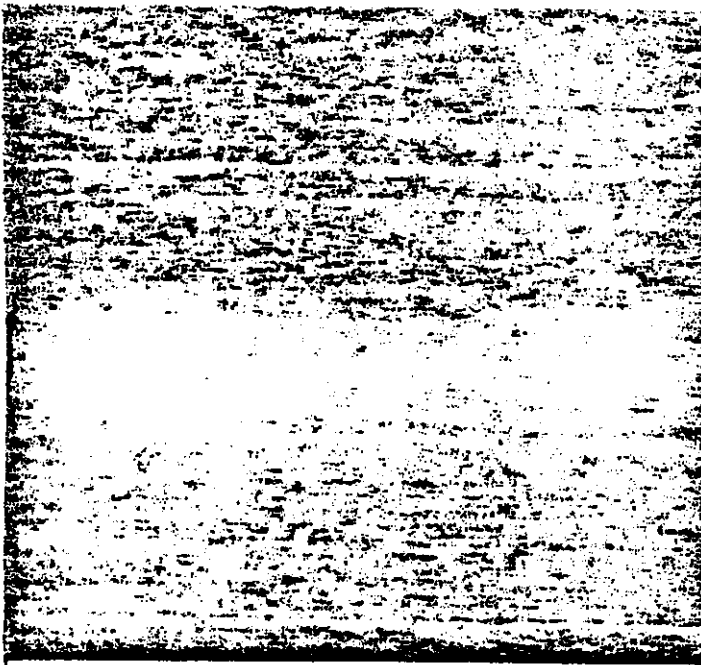


Graph 1

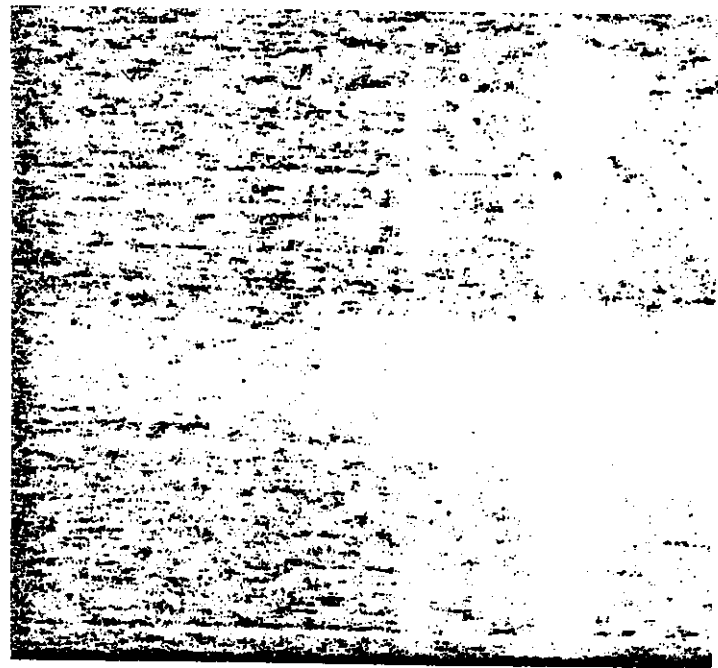
in two minutes when the oxygen was removed. When the ulcers were exposed to air instead of oxygen in the bag, the values of PO_2 were oscillating between 30-60 mm of Mercury.

When nitrogen was used, a drop in the PO_2 value was observed to an average of 12 mm of Mercury in the first five minutes and then stabilization to an average pressure of 4.5 mm of Mercury. Since, in this case, any source of outside oxygen was eliminated, the values obtained represent an arterial supply of oxygen.

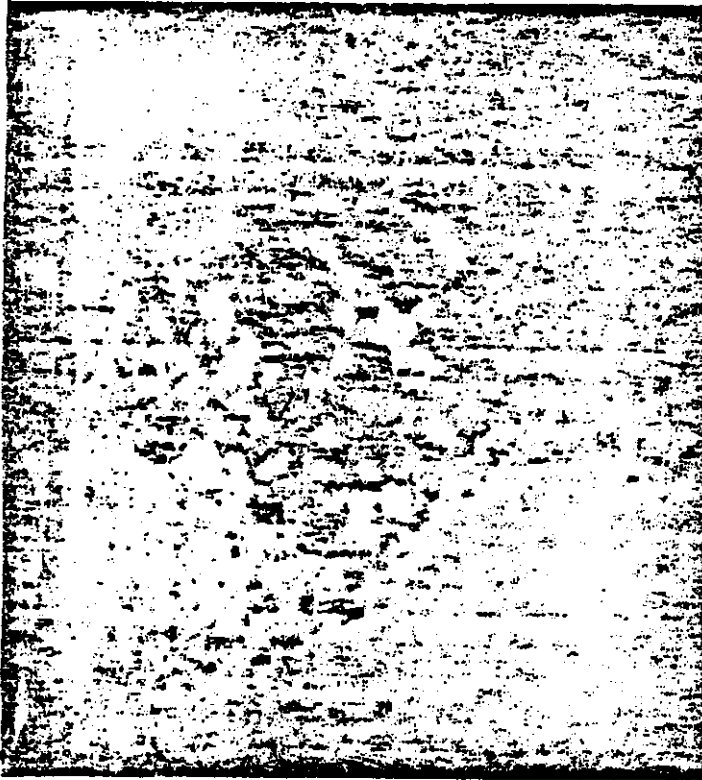
Our studies were conducted both at 12 mm of Mercury above atmospheric pressure and at atmosphere, and the results were almost the same in both. There was only a very negligible difference in the values.



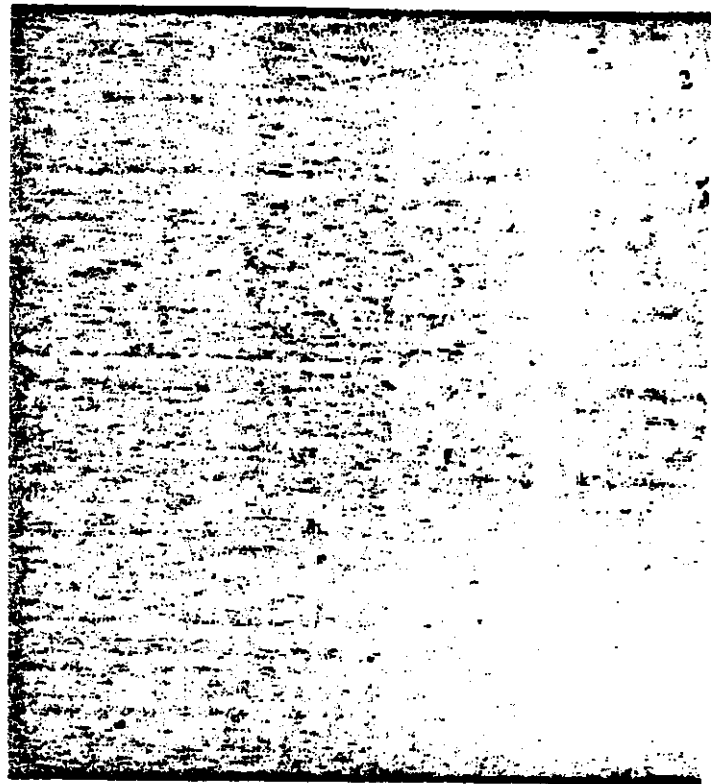
1. Cellulitis is plainly visible prior to therapy.



2. After three weeks of oxygen therapy.



3. After six weeks of oxygen treatment.



4. After ten weeks the ulcer is almost healed.

Stasis Ulcers of Two Years Duration—The patient was a 78-year-old man with peripheral vascular disease. His leg ulcers had been unsuccessfully treated for two years with other modalities. The four photos show his leg ulcers and how they healed during a course of oxygen therapy.

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Results of Treatment

(Leg Ulcers Exposed to Oxygen Under 12 mm of Mercury—1964—1972)

Etiology	Total Patients	Female	Male	Healed	Not Healed
Phlebitis	91	47	44	87	4
Varicose Veins	11	6	5	11	0
Arteriosclerosis	33	20	13	10	23
Post Traumatic	33	15	18	33	0
Sickle Cell Anemia	4	4	0	1	3
Lupus Erythematosus	2	1	1	0	2

Table 1

soaks. Since all these methods had failed, the patients were referred to us for treatment with topical oxygen.

In some patients, we compared the results of healing by using hydrotherapy with topical oxygen. During the time hydrotherapy was employed, we observed the progress of healing by measuring the size of the ulcers and changes taking place within them. We noted that debridement was slower and not complete in comparison with topical oxygen application. The edges of the ulcers were very slow in healing and less granulation tissue filled the ulcerations.

When the treatment was changed to topical oxygen, the progress of healing was visibly accelerated. There was rapid debridement and growth of granulation, and the edges of the ulcer closed.

From our own experience and studies throughout the years, the method of topical oxygen application, as described, was established as superior to any other method.

Supported by the Wayne County General Hospital Medical Staff Research Fund, and first presented at the AMA meeting, June 1974, Section on Physical Medicine and Rehabilitation.

Causes and Results

The statistical data of 174 patients treated from 1964 to 1972 in Table 1 shows the final results of treatments, with sex distribution of the patients and etiology of the ulcers. There were 93 women and 81 men treated. In ulcers of different etiologies, all 33 patients with posttraumatic ulcerations and 11 patients with varicosities had complete healing of the ulcerations. Of 91 patients with postthrombophlebitis and venous insufficiency, 87 or 95% healed. The least improvement was noted, as expected in patients with arteriosclerotic ulcerations. Only 10 out of 33 were healed, 33% successfully. This could be understood considering the diminished blood supply through the sclerotic vessels to the ulcerated areas. Most of the patients in this category stated that while being treated, they had marked relief from pain.

In general, we can say that all ulcers, regardless of etiology, show initial improvement. Only the general physical status of the patient and etiology of involvement would determine complete healing.

The rate of healing was very difficult to

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Recordings of PO_2 from deeper layers of the granulation tissue were less satisfactory. We encountered difficulty in determining exactly how deep the tip of the electrode had been inserted. In addition, there were technical difficulties, mentioned before, as the electrode insertion caused local hemorrhage, and pressure caused ischemia of the tissue.

The control values of PO_2 in granulation tissue exposed to the air at a depth of 1 mm were lower than in the surface of the ulcer, with values oscillating from 15–30 mm of Mercury.

When the electrode was 1 mm or more under the surface of the granulation tissue, there was little or no change in the PO_2 during exposure of the surface to pure oxygen in the bag.

These results indicate that during low hyperbaric treatment, high oxygen saturation takes place in the plasma covering the ulceration and in the superficial layers of the granulation tissue.

The experiment with nitrogen shows that the outside environment of the ulcer is a very important source of oxygen for regenerating epithelial tissue. The oxygen supply to deeper layers of the granulation tissue comes mostly from the vascular bed, which could explain poor results from topical oxygen application in cases of advanced arteriosclerosis, when the delivery of oxygen to the tissue is markedly diminished.

Clinical Observations

Within a few minutes after treatment has begun, the color of the granulation tissue may change rapidly from dark to bright red. There is a marked lessening of pain and discomfort in patients with arteriosclerotic ulcerations.

The healing process seems to consist of two phases:

- The first is a cleansing, self-debriding period lasting from one to 10 days. The exudate disappears and necrotic tissue falls away. Fresh red granulation appears on the surface of the ulcer and new, well outlined edges can be seen clearly.

- In the second stage, there is a rapid growth of granulation tissue filling the ulcer at the same pace with epithelium. On many occasions following the first stage, some small islands of preserved skin appear in the ulcer, growing in size and join with each other to rapidly cover the ulcer. Saline solution dressings help to maintain an optimal physiological condition for the healing process.

Patients with venous insufficiency are advised to use ace bandages to control lymphedema by promoting better venous return, nutrition, and faster healing.

Concerning the role that oxygen plays in the treatment regimen, we feel it has a stimulating effect on the body defense and repair mechanisms, such as phagocytosis, the growth of granulation tissue, and sometimes bacteriostasis. We did not routinely culture the bacteria from the ulcers. However, we did identify the pathogens and frequently found *Staphylococcus aureus* and *Escherichia coli*, which usually disappear before the ulcer is completely healed.

The Patient's Control Studies

To determine the validity of the method of treatment, each patient presented with their own "control study." Most of our patients had employed different modalities over a few months, or even a few years, using antibiotics, compressive dressings, ointments, and

estimate but progress could be observed almost daily. We did not use any antibiotics, parenterally or externally applied, or any ointments.

Conclusions

The method of treatment of leg ulcers, which includes topical oxygen application as described, is very effective and superior to any other method of treatment. The main problem is to find the proper ratio of tissue and O₂ pressure to stimulate, not impede, the growth of granulation and epithelial tissues.

Favorable conditions for action of phagocytes and growth of the epithelium depends on optimal oxygen tensions and times of exposure.¹⁰⁻¹²

Further studies in topical oxygen application should be investigated for surgical wound healing and skin grafting. Our limited experience in this area indicates that the method is very effective. We also used topical oxygen for

treatment of decubitus ulcers in patients with spinal cord injuries through a funnel or body bags and, again, the results were good. ◀

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