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TREATMENT OF PRESSURE SORES AND
SKIN ULCERS**

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Reprinted from THE LANCET, August 23, 1969, pp. 405-409

TOPICAL HYPERBARIC OXYGEN TREATMENT OF PRESSURE SORES AND SKIN ULCERS

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Summary Hyperbaric oxygen was used topically to treat pressure sores and skin ulcers. Specially constructed devices equipped with controlled pressure sealings and automatic relief valves were used. A constant pressure of 22 mm. Hg (1.03 atmospheres absolute) was maintained inside the chamber using pure oxygen at a flow-rate of 2-8 litres per minute with direct discharge to atmosphere. Bacterial growth was suppressed, granulation was enhanced, and epithelium formed. Vascularisation seemed to be important to success. Topical hyperbaric oxygen treatment was tolerated well. It shortened the healing-time and was also useful in the preparation for plastic-surgery repair. No adverse reactions were noted. 52 patients were treated successfully; 6 others, with bilateral lesions, took part in a controlled trial of hyperbaric oxygen; and there were 6 failures (4 with an underlying osteomyelitic lesion).

Introduction

THE beneficial effect of hyperbaric oxygen on some wounds and skin lesions¹⁻⁴ suggested that similar effects might be expected if topical hyperbaric oxygen were used to treat skin ulcers and pressure sores.

Methods

The approach differed substantially from the hyperbaric tank concept in that a localised hyperbaric chamber was created around an area of skin lesion. Inconveniences and risks associated with the exposure of patients and staff to increased oxygen tension was thus eliminated, with significant gains in ease of nursing-care.

Various devices were developed according to the type and location of the skin lesion (fig. 1). They consisted of rubber or vinyl sheets forming tube-like chambers applied over lower extremities separately or in the form of pants with sealings around the thighs and waistline. Hermetic outlets for catheters secured unobstructed urinary flow. Hip and

sacral decubiti were treated using polystyrene cups, contoured according to body line and held in place by 'Velcro' straps. Automatic relief valves maintained the pressure inside the chamber at a constant 22 mm. Hg (1.03 atmospheres absolute), using pure oxygen at a flow-rate of 2-8 litres per minute with direct discharge to the atmosphere. Since the capillary pressure of the human skin ranges between 16 and 33 mm. Hg,⁶ I used an arbitrary-pressure of 22 mm. Hg to avoid a significant ischaemia. The risk of ignition from static electricity was reduced by using humidified oxygen; at the same time this reduced the excessive drying effect of circulating oxygen on ulcerations.

For chambers with controlled sealing pressure, oxygen was applied continuously for 4-12 hours per day. With the polystyrene cups, intermittent oxygen exposure was applied either 1 hour on and 1 hour off around the clock or for a total of 4-8 hours per day. (Since the cup device encloses a very narrow area around the ulcerative lesion exerting uncontrolled pressure necessary for sealing, the intermittent type of oxygen application was used to avoid any major obstruction of the local vascular bed.)

During intervals between oxygen treatment the lesions were dressed with gauze sponges soaked with physiological saline solution. No other local or parenteral agents were used during the course of hyperbaric oxygen treatment. Surgical debridement was done only when the lesion was severely necrotic, usually on the second or third day after start of treatment, when a well-delineated demarcation line between the vascularised and necrotic tissue had developed. Thus unnecessary additional trauma was avoided, and viable tissue was spared. Bacterial cultures of swabs from the lesions were done serially in all cases. All lesions treated, except for two sacral pressure sores and the accidental trauma group, were of at least four months' duration, and previous treatment using various methods had been unsuccessful. The traumatic lesions were treated one day and five days respectively after the trauma. The patients ranged in age from nine to eighty-four years.

Results

UNCONTROLLED TRIALS

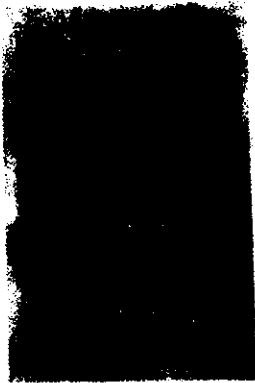
Lesions of the Lower Extremities

Superficial ulcers due to diabetes (2 cases).—The lesions had been present four and five months before start of oxygen therapy, presenting as true superficial ulcers without gangrene. They were located between the first and second, and fourth and fifth toes. In both cases *Staphylococcus aureus* was identified. The infected area rapidly became almost aseptic, and enhanced granulation was noted after two days of therapy. The lesions healed within six and nine days.

Ulcerations due to venous stasis (16 cases).—All



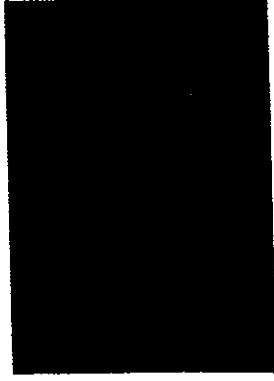
(a)



(a)



(a)



(a)



(a)



(a)

Fig. 4—Chronic discharging osteomyelitis of 13 months' duration in a 60-year-old patient.

(a) At start of hyperbaric-oxygen therapy.
(b) After 7 days' oxygenation at 8 hours (consecutive) per day. Oxygen discontinued.

Fig. 3—Pressure sore of midcalf area of 4 months' duration in a 18-year-old quadriparetic.

(a) At start of hyperbaric-oxygen therapy.
(b) After 22 days' oxygenation at 8 hours (consecutive) per day.

Fig. 2—Ulceration of left lateral ankle area of 24 years' duration in a 55-year-old patient.

(a) At start of hyperbaric-oxygen therapy.
(b) After 30 days' oxygenation at 8 hours (consecutive) per day.

TABLE I—CONTROLLED TRIALS OF HYPERBARIC OXYGEN IN THE TREATMENT OF BILATERAL LESIONS

Case	Age (yr.)	Sex	Diagnosis	Left side	
				Right side (hyperbaric oxygen)	Conventional treatment
1	26	M	Paraplegia; bilateral hip decubiti, 4 cm. diameter, 8 mo. duration	Healed, 7 wk.	Conventional treatment Healed, 6 wk.
2	65	F	Venous insufficiency; bilateral tibia ulcers, 3 x 1 cm., 9 mo. duration	Healed, 3 days	Mild improvement Healed, 3 days
3	65	F	Venous insufficiency; bilateral tibia ulcers, 5 x 3 cm., 8 mo. duration	Healed, 15 days	No improvement Healed, 14 days
4	73	F	Venous insufficiency; bilateral tibia ulcers, 5 x 4 cm., 13 mo. duration	Healed, 17 days	No improvement Healed, 17 days
5	20	M	Paraplegia; bilateral heel decubiti, 2 x 2 cm., 7 mo. duration	Healed, 7 wk.	Mild improvement Healed, 6 wk.
6	67	F	Right hemiparesis, bilateral decubiti separated by intergluteal fold, 3 x 2 cm., 5 mo. duration	Healed, 14 days	No improvement Healed, 15 days

wound with some drying was the only response observed in these trials. Nevertheless, oxygen under ambient pressure may exert some healing effect,⁸ though the healing-time required prolonged exposure (up to seven months) as compared with an average of three weeks using oxygen under pressure on similar lesions. This fact indicates the crucial importance of pressure under which oxygen is applied. Since different exposure-times were used on lesions similar in type and size, the efficacy of oxygen treatment in relation to the time of exposure could be investigated. The best results were obtained with oxygen for six to eight hours per day. There was no significant shortening of healing-time when exposure was increased to twelve hours per day. Healing took longer in lesions exposed to hyperbaric oxygen for only four hours per day. In all lesions a prompt arrest of bacterial growth was noted leading frequently to asepsis or only sparse bacterial growth. No lesion was infected with *Pseudomonas aeruginosa*. I suggest that the encouraging results observed during the topical hyperbaric-oxygen treatment are due to the inhibitory action of hyperbaric oxygen on certain bacteria, and the relief of relative hypoxia in the damaged tissue by oxygen absorption through the lesion, resulting in accelerated metabolism in the damaged tissue, stimulation of capillary growth, and stimulation of granulation and epithelium formation. It is reasonable to presume that there may be a substantial oxygen absorption through open wounds; this would augment the oxygen supply in an area of disturbed circulation.

Topical hyperbaric oxygen is not a panacea. If used judiciously in suitable cases it can be of enormous help to the patient and to the doctor, reducing suffering and enabling reablement to be started earlier. There were no fires during the entire period of trials covering four years; the procedure was well tolerated by all patients, and no adverse reactions were noted.

I thank Dr. Clark T. Randt, Dr. Howard A. Rusk, and Dr. Joseph Ransohoff for their support. Becton, Dickinson and Co. in Rutherford, New Jersey, supplied the therapeutic equipment.

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