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HYPERBARIC OXYGEN THERAPY IN DERMATOLOGY

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Summary.—Successful results are reported with hyperbaric oxygen treatment of 6 dermatological cases in which previous methods of therapy have been unsatisfactory. In one case of advanced generalized scleroderma, regression of the skin contraction was achieved, together with improved mobility of joints and healing of persistent ulcerations. In 2 cases of severe arterisoclerotic leg ulcers healing of the ulcers was achieved without mutilating operations. In one case each of progressive pyoderma gangrenosum, ulcer of Felty's syndrome and fulminant bullous haemorrhagic erysipelas, full healing of the ulcers was also achieved. The nursing periods were undoubtedly greatly shortened, and the hyperbaric treatment could to a large extent be given on an ambulatory basis. No adverse side-effects were observed.

OXYGEN treatment at elevated atmospheric pressure is an effective but hitherto little used method of counteracting local tissue hypoxia due to restricted peripheral circulation. Of dermatological interest is the use of this method for the treatment of poorly healing or persistent ulcers, especially as the suppression not only of anaerobic but also of aerobic infections has been observed (McAllister *et al.*, 1963; Irvin and Smith, 1968). The method has been used for the treatment of leg ulcers of both arteriosclerotic and varicose character (Illingworth, 1962; Bird and Telfer 1965; Slack *et al.*, 1966; Barthèlemy *et al.*, 1967; Mantz and Tempe, 1968; Besznyák *et al.*, 1968; Shaldin, 1969; Barr and Benson, 1970; Bass, 1970; Kidokoro *et al.*, 1970; Lefebvre *et al.*, 1970).

Other than leg ulcers only a few dermatological diseases seem to have been subjected to hyperbaric oxygen treatment. Duluc *et al.*,(1968) reported 3 cases of psoriasis. One case of purpura fulminans was reported by Wadell *et al.* (1965) and another was reported by Kuzemko and Loder (1970). Three cases of chronic undermining ulcer of Meleney were reported by Grainger *et al.* (1967). Dowling *et al.* (1967) reported a good effect on Raynaud's phenomenon in 6 cases of scleroderma.

In the present study the use of hyperbaric oxygen (HPO) has been extended to certain pathological conditions in which local circulatory insufficiency is evident and/or the healing process needs an unduly long period of hospitalization.

MATERIALS AND METHODS

Six patients are presented: one suffering from generalized scleroderma, one from pyoderma gangrenosum, one from Felty's syndrome, one from bullous haemorrhagic erysipelas and 2 from arteriosclerotic leg ulcer.

The treatments were all given in a one-man plexiglass pressure chamber (Vickers type CH S/3) at a pressure between normal and 2·5 times normal atmospheric pressure, i.e.

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at 1–2·5 atmospheres absolute pressure (atma). The pressure was increased in 5–6 min, kept constant for 1–1·5 hours and lowered in 3–4 min. A continuous flow of oxygen (300 l/min) passed through the chamber during the treatments to avoid rebreathing of CO_2. As a routine, all patients had the lungs controlled by x-ray and the eardrums and Eustachian tubes checked before the first treatment. Only exceptionally was pre-medication (100 mg pentobarbital) given.

Case Reports

Case 1.—A.S., a woman aged 33. Diagnosis: generalized scleroderma.

For 3 years the patient had suffered from progressive generalized scleroderma, which had been treated with corticosteroids, immunosuppressive agents and antibiotics without effect. At the start of HPO the patient was seriously disabled, with a pursed mouth, and almost no mobility in finger, wrist and elbow joints. Minor ulcerations over these joints were also present, as well as a palm sized infected ulcer over the right medial malleolus. After 3 weeks of HPO, the scleroderma process was apparently arrested. Both the patient and her relatives spontaneously reported that the skin had become less tense and of a healthier colour, and that joint mobility was increased. After 7 months of treatment a further regression of the scleroderma was seen. Thus there was less stiffness in the joints and an almost normal facial expression. The leg ulcer was healed with autografts from the abdomen. In all 328 HPO treatments were given in 9 months. The good condition still persists 5 months after the end of treatment.

Case 2.—G.K., a man aged 49. Diagnosis: ulcerative colitis and pyoderma gangrenosum.

He had suffered repeated attacks of ulcerative colitis and pyoderma gangrenosum for 7 and 6 years respectively. HPO, 3 years ago, primarily intended to eradicate anaerobic bacteria in the bowel, had been found also to promote healing of the leg ulcer. A new ulcer appeared after 2 years. This time HPO showed no significant effect until the treatment was intensified from 1 hour at 2 atma once a day to 1 hour at 2·5 atma 2–3 times a day. The ulcer healed after 81 treatments.

Case 3.—M.H., a woman aged 54. Diagnosis: rheumatoid arthritis and leg ulcers (Felty's syndrome).

Rheumatoid arthritis, present for 16 years, had been treated with continuous oral steroid therapy for 13 years. In the last 4 years the patient has been repeatedly hospitalized for a total of 22 months with leg ulcers of the type seen in Felty's syndrome. After 6 weeks of HPO the appearance of bright red granulations allowed the ulcers to be covered with split-skin grafts. The patient was discharged fully healed after 3 months and 99 hours of treatment. There has been no recurrence during 10 months of observation.

Case 4.—E.T., a man aged 67. Diagnosis: bullous haemorrhagic erysipelas.

Erysipelas, with multiple haemorrhagic bullae, developed on the left lower leg. Despite adequate penicillin treatment, according to bacterial cultures, 6 large deep ulcers had appeared 1 month after the onset. Within 2 days of the start of HPO, red granulations could be seen among the necrotic tissues. The condition progressively improved and, after 3 months and 130 hours treatment, 5 of 6 ulcers were completely healed. There was no recurrence during 7 months of observation.

Case 5.—S.B., a woman aged 56. Diagnosis: leg ulcer (arteriosclerotic).

A rapidly growing, pretibial ulcer on the left lower leg developed after a slight injury. About 7 weeks later the ulcer almost encircled the leg. Femoral angiography showed the common iliac artery to be totally obliterated 4 cm distal to the bifurcation. Via the collateral circulation contrast filling of the vessels was obtained about 15 cm distal to the obstruction. Despite intense local treatment and systemic chemotherapy, the ulcer grew to a 20–25 cm wide gaiter surrounding the leg. Amputation was recommended repeatedly, but the patient refused. As a last resort, it was decided to start HPO.

After about 1 month it was possible to apply split-skin grafts. HPO was continued. The patient was discharged healed 3·5 months after the start of HPO and she resumed her occupational activities to the full extent 2 months later. One year later the skin is still intact.

Case 6.—E.L., a man aged 67. Diagnosis: leg ulcer (arteriosclerotic).

The right femur was amputated 2 years ago. Six months later a gangrenous, severely painful ulcer on the sole of the left foot appeared and grew to 5 × 6 cm in 2 months. In the femoral artery satisfactory pulsations could be felt, but none in the popliteal, posterior tibial or dorsal arteries of the foot. Oscillometry suggested stenotic lesions. After 6 weeks of HPO (total 69 hours) the ulcer was fully healed. At a follow-up 11 months later there were no signs of recurrence.

DISCUSSION

There is at present no satisfactory therapy for generalized scleroderma. Corticosteroids do not appear to affect the process. The value of immunosuppressive therapy is the subject of much discussion. Low molecular weight dextran has been tried, especially when acrosclerosis is present. The patients have felt a little warmer in the fingers, and ulcerations have healed, but renal complications have occurred. Our patient (Case 1) was in an advanced stage of the disease and was well aware of the poor prognosis when the hyperbaric oxygen treatment was introduced. The physical improvement had a positive psychological effect on the patient as well as on her family, and the increased mobility meant that she needed less help with daily attendance. The treatment admittedly did not eliminate the disease, but led to a distinct regression of the lesions. Even if the patient should need recurring treatment periods in the future, this therapy is well justified despite its cost in time and money. The successful healing of the ulcer on the leg as well as the graft donor site seems to indicate that the hyperbaric treatment has eventually normalized the healing capacity of the diseased skin.

Pyoderma gangrenosum is not uncommon in patients with ulcerative colitis, but often appears also in patients with rheumatoid arthritis. Apart from treatment of the basic disease, the therapy of the skin lesions has been solely symptomatic. In rheumatoid arthritis other types of leg ulcers also occur. One type is seen in Felty's syndrome, in which the ulcers are often multiple, painful, slowly healing and frequently recurring. In the patient with pyoderma gangrenosum (Case 2) and in the patient with an ulcer of Felty's type (Case 3) the hyperbaric treatment led to a marked shortening of the expected hospitalization periods. In the pyoderma gangrenosum case no positive effect was obtained until the pressure had been increased to 2·5 atm and the duration of treatment had been prolonged to 1·5 hours on each occasion. In the patient with an ulcer of Felty's type, the treatment with oxygen had to be continued after the split-skin graft. In accordance with our earlier experiences with hyperbaric oxygenation, the best survival rate for the split-skin coverings was gained with the oxygen pressure in the chamber limited to 1 atm, i.e. pure oxygen at normal atmospheric pressure, during the first few days after application.

The patient with bullous haemorrhagic erysipelas (Case 4), who quickly developed large, deep, purulent necrotic ulcers, would most likely have needed extensive skin grafts, and perhaps even amputation, but for the use of the hyperbaric chamber. In future we intend to start oxygen treatment of such cases of severe,

bullous haemorrhagic erysipelas at the earliest possible stage of the disease, hoping to reduce the spread in depth and thus shorten the time of treatment.

Several authors (Slack *et al.*, 1966; Barr and Benson, 1970; Bass, 1970) have reported the favourable effect of hyperbaric oxygen on leg ulcers caused by venous insufficiency, with inhibition of bacterial growth, increased vascularization and improved epithelialization. The value of hyperbaric oxygen on arteriosclerotic leg ulcers, on the other hand, has been less conclusive (Gorman *et al.*, 1965; Fischer, 1969; Bass, 1970). In these cases the patients have as a rule been very old, and the treatment was given as a last resort when the usual means of therapy had been exhausted. Slack *et al.* (1966) mentioned that the limited treatment programme they used, with only one session a day, might be responsible for their poor results. The positive effect in Case 5, in which the patient was treated up to 3 times daily, seems to confirm this hypothesis. The control period of only 12 months is rather short; but, even if the treatment had to be resumed in the future, much has been gained, as the alternative was amputation. The relatively low age of this patient, 56 years, may have been favourable with respect to her ability to develop collateral circulation. The other patient (Case 6), with an ulcer of arterial type, was also saved from an imminent amputation.

The results of treatment in the 6 cases presented show that the hyperbaric oxygen technique may have important therapeutic potential in dermatology. It attacks the problems from a new angle, which definitely leads to shorter periods of treatment and sick leave. Further, it is gratifying to note that ambulatory treatment could be applied to a large extent. No troublesome side-effects have been observed.

A short summary of the physiological background to hyperbaric oxygenation and the practical implications of its use may be helpful for those not familiar with this relatively new form of treatment.

An increase in the partial pressure of the oxygen in the lungs from 100 mm to 1500–2000 mmHg will cause a proportionately greater quantity of oxygen to be taken up by the arterial blood in physically dissolved form. It is thus possible, at least partly, to compensate for a decrease in the blood flow by an increase in the oxygen content of the blood. Further, the increased partial pressure of the oxygen in the blood will increase its capacity to diffuse into the tissues from the vascular bed. A direct local effect of the ambient oxygen on open and often infected wound surfaces is also considered to improve the healing conditions. A persisting effect, probably due to local revascularization, appears to be attainable also in elderly patients when subjected to extended treatment programmes. To achieve a sufficiently high oxygen pressure, the atmospheric pressure around the patient has as a rule to be increased to 1–2 atmospheres gauge pressure (atmg), corresponding to 2–3 atmospheres absolute pressure (atma). The hyperbaric oxygen treatment, therefore, needs special pressure chambers accommodating one or more persons. To avoid oxygen cramp and lung injury, each treatment should not exceed 3 atma and should not last longer than 2 hours. Instead, the exposure should be repeated one or more times per 24 hours. If necessary, the treatment may be extended over several months. There is no risk of decompression sickness, due to nitrogen bubbles appearing in the blood when the pressure is lowered, as only oxygen is breathed. The greatest risk is, rather, oxygen intoxication. The oxygen fits or cramps, however, quickly disappear on lowering the pressure, and the treatment can be continued on the following day. The pressure equilibration in the

middle ear during the raising of the pressure, as a rule presents no problems. It should be mentioned, however, that, during very extended treatment programmes at higher pressure levels, a cataract-like clouding of the lens in arteriosclerotic patients has been seen (Pallin and Barr, 1972). The indications for excessive hyperbaric oxygen treatment should thus be relative and the advantages of, for example, a saved limb should be weighed against the eventuality of a future cataract operation.

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