Scope and Limitations of Hyperbaric Oxygen Therapy*

BRIGADIE R. RASAMAY GANGULY, AVSM., VSM**

Introduction :

Over the past fifteen years there has been a great deal of investigations into the effect of breathing oxogen at tension higher than normal. Most of the works have been carried out in various Services Institutions. and Space Research Agencies throughont the world.

The other groups, who have explored the possibility of hyperbaric oxypen administration, and medical men, who have been trying to find new methods of treating various conditions in which hypoxia is a feature, or attempting to createan environment, which will prove inimical to the growth of pathogenic organisms.

Physiological Consideration :

Whiie breathing air at sea level the alveolar Po_2 is about 100 mm. Hg. and the haemoglobin is 97 to 98 per cent saturated with oxygen, carrying 19.5 volumes per cent of the gas in combination, whereas hardly 0.3 vol. per cent of the gas goes into physical solution in plasma. If pure oxygen is breathed, its alveolar partial pressure eventually reaches about 670 mm Hg. and the total oxygen content of arterial blood is elevated to 22 volumes per cent. Since haemoglobin requires only a small fraction of the additional amount of oxygen for complete saturation most of the oxygen wiil go into physical solution (2 volums per cent). Further increases in the P_{O2} serve only to increase the amount in physical solution since haemoglobid is already completely saturated. Thus by an increase of pressure to 2 atmospheres absolute (ATA) the total volume of physically dissolved oxygen in 100 ml. of arterial blood is appioximately 4 ml; at 3 ATA., 6 ml. etc.

The oxygen available for cellular consumption is that dissolved in plasma. The volume of the gas normally utilised is about 6 ml. per 100 ml. of arterial blood, the quantity in solution at a partial pressure of 3 ATA. Thus at this and higher

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** Professor and Head of the Department of Surgery, Armed Forces Medicai College, PUNE-1.

partial pressure of oxygen the function of haemoglobin becomes unnecessary fo maintenance of life.

Though it is easy to raise the oxygen tension of arterial blood by forcing a person to breath oxygen under pressure, it is not so easy to raise the tension of oxygen in the tissue to a correspondingly high level. This is because, with the rise of arterial oxygen tension, there is a fall in cardiac output and rise of peripheral resistance caused by vasoconstricting action of oxygen on the arterial wall In fact, there is a reduction of blood flow in practically every organ in the body ; but despite this fall the increase in the arterial oxygen content usally more than balances any deficiency brought about by the reduced blood flow, and may even create the problem of oxygen toxicity.

Methods of Administration :

Two methods are available for administration of oxygen under high pressure. In the one man pressure chamber where oxygen is the compressing gas the patient not only breathes oxygen under high pressure but his body is also subjected to the same high pressure of oxygen. In the larger hyperbaric chambers capable of holding not only the patient but also a number of medical attendants, only the patient breathes oxygen under high pressure through a close fitting mask or endotracheal tube while the attendants are subjected only to a high pressure of air.

Cleanical Applications :

The value of hyperbaric oxygenation has been proved beyond doubt in certain clinical conditions, whereas in many other fields its usefulness is still under exploration. For the purpose of discussion we may group various disease conditions under few broad heads.

A. Generalised Hypoxia :

1) Carbon-Monoxide Poisoning :

Coal gas poisoning was once a popular method of suicide. Accidental poisoning still occurs in elderly people with impaired senses, living in small rooms with charcoal burning to keep them warm. Carbon-monoxide exerts its harmful nffects by blocking the carriage of oxygen by haemoglobin, and by affecting its dissociation at the tissue level. With hyperbaric oxygen at 2 atmosphere, there is immediate correction of tissue hypoxia by the extra oxygen dissolved in the plasma, and improvement in the dicsociation of carboxy-haemoglobin.

2) Myocardial Infarction :

The role of hyperbaric oxygen in this condition is stiil controversial. Animal experiments have shown that hyperbaric oxygen affords protection against ventricular fibrillations after ligation of coronary arteries. Cardiogenic shock, following myocardial infarction, may interfere with adequate oxygenation of tissue, due to pulmonary shunting of blood. Hyperbaric oxygen may be added to the intensive coronary-care, to raise the level of arterial oxygee, correct metabolic acidosis, and control Ventricularly ythmias. Based on the above hypothesis, it has also been

used for the treatment of Irreversible shock due to servere haemorrhage with varying degree of success.

B. Regional Ischaemia :

1) Peripheral vascular diseases :

Surgeons have often turned hopefully to hyperbaric oxygen, as an additional form of conservative treatment, in the management of indolent ulcers caused by atherosclerosis or thromboangeitis obliterans. Though claims have been made that hyperbaric oxygenation can alleviate rest pain, and heal chronic ischaemic ulcers, it should be realised that intermittent exposures, lasting for two hours a day, can only have short-lived beneficial effects in a progressive degenerative vascular disease.

2 Arterial injuries :

In traumatic ischaemia, following compound fractures or gun-shott injuries, the role of hyperbaric oxygen is more readily understood. The treatment is designed to prevent the occurance of local hypoxia, during the time that collateral vascular development is taking place. Where prompt surgical restoration of adequate blood supply is not feasible, hyperbaric oxygen, combined with decompressing surgical incision, may relieve tissue anoxia and thereby save the limb from amputation.

3 Transplantation procedures :

Hyperbaric oxygen has been used to improve the survival of pedicle grafts threatened by ischaemia. It has also helped in transplantation of limbs during the critical period of their survival. Hyperbaric oxygen, combined with hypothermia and some form of perfusion, may prove helpful in the preservation of organs prior to their transplantation.

C. Bacterial Infection :

1) Anaerobic

Hyperbaric oxygen therapy is a real advance in the management of anaerobic gas-gangrene, which often results in extensive mutilating surgery, amputation of limbs or death of the patient Hyperbaric oxygen is known to inhibit the growth and production of alpha-toxins by Clostridium welchii. Two hourly sessions of hyperbaric oxygen, given twice a day for 3 or 4 days, under three atmospheric pressure, always leads to dramatic amelioration of toxic symptoms and arrest of further spread of the disease. For the ultimate survival of the patient, it is however mandatory to remove necrotic tissues, but with hyperbaric oxygen, surgery can be less radical and spare many muscles with border-line viability.

Although in vitro experiments with Clostridium tetani have shown a high rate of inactivation of bacterial growth, clinical response to hyperbaric oxygen is not as dramatic as in gas-gangrene, because, the toxin gets fixed to the nerve cells before clinical manifestations appear.

2) Aerobic

Clinically encouraging results have been

reported in the treatment of long standing suppurative osteomyelitis, and in combating pyocyaneus infection in case of burns. To avoid oxygen-toxicity to the patient, in the treatment of such cases, modified Bunyan-bags filled with oxygen have been used to enclose the affected limb, with the patient inside the pressure chamber, breathing only compressed air.

3) Fungal

Sufficieni trials have not been given to hyperbaric oxygen in the management of Madura foot – an anerobic fungal infection, so common in our country, and for which we have so very little to offer in way of treatment. The possibility of treating these cases in our hyperbaric centre at Bangalore should be explor ed.

D. Malignant Diseases :

The rationale of treatment of malignant disease with hyperbaric oxygen, combined with radiotheraphy, is based on the presence, in most malignant tumours, of some degree of cellular hypoxia These cells are relatively insensitive to ionising radiation and therefore provide a nucleus for continued activity following treatment. High pressure oxygen raises the oxygen tension of such cells into the range where sensitivity to radiation is normal. Hyperbaric oxygen have also been combined with various chemotherapeutic drugs to prolong survival time of patients suffering from cancer.

E. Other Applications of HBO :

In the treatment of decompression sickness, hyperbaric oxygen helps to reduce the size of gas bubbles in blood vessels or tissues. It has also been used unsuccessfully to treat cerebral air-embolism following open heart surgery, for treatment of surgical emphysema, and even to reduce gaseous distension of intestine in paralytic ileus, with varying degree of success. Hyperbaric oxygen is known to play a definite role in healing of all wounds and regeneration of surface epithelium. Some workers have claimed, that even gastric ulcers have been cured and symptoms of regional ileitis have disappeared under this form of therapy. But the most exciting of all claims is that hyperbaric oxygen have shown a promise of arresting senility by improving blood supply to cerebral cortex and thereby, the memory, cognition and intelligence in ageing people.

Conclusion :

The use of HBO in a variety of conditions has been discussed. It is proved that HBO has a definite place in several clinical condition. However, widespread use of HBO has got limitations due to oxygen toxicity and other associated danger.

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