Clinical Aspects of Hyperbaric Oxygen and Radiotherapy

New York Experiences

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The role of oxygen as a powerful modifier of radiation injury in the biological system has been well recognized. However, a significant improvement in clinical result in the radiotherapy of human cancer with hyperbaric oxygen has not yet been established. A clinical study of this kind is difficult because of variations in radiation treatment technique, oxygen pressure, fractionation and case material. Of special interest in the clinical study is the degree of normal tissue reaction, the tolerance of patients to the procedure, the complication and finally the cure rate. Of special importance is the plan of the clinical trial and study for maximum information which should be worked out with bio-statisticians before starting the clinical project.

Our experience with hyperbaric oxygen at the Columbia-Presbyterian Medical Center consists of an initial pilot study and subsequent randomization of patients with advanced cancer of the head and neck using hyperbaric oxygen at 4 atmospheres from 1960 to 1963 and an extension of the clinical study to include glioblastoma multiforme and bilateral pulmonary metastases using hyperbaric oxygen at 3 atmospheres from 1963 to date. A brief resume follows:

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69

I. Radiotherapy under hyperbaric oxygen at 4 atmospheric pressure: In the non-oxygen control group, it was found that a tumor dose of 3250 r given in 3 fractions of 1250 rad, 1000 rad, and 1000 rad at weekly intervals produced results comparable to 6000 rad in 6 weeks with conventional fractionation and complications are not increased. In the hyperbaric oxygen group, it was found that the corresponding radiation dose at oxygen pressure of 4 atmospheres should be 2200 rad in 2 treatments spaced a week apart. This produced a reaction in normal tissue similar to that seen in non-oxygen control group. This demonstrated that a dose-reduction factor of 14–15 is present in the oxygen treated group as far as normal tissue tolerance and complication rate are concerned. In October, 1960, a randomized study was begun. This consists of 3 groups of patients: (1) receiving radiotherapy with unconventional fractionation under hyperbaric oxygen; (2) receiving radiotherapy with unconventional fractionation under no hyperbaric oxygen; (3) receiving radiotherapy with conventional fractionation, 6000 rad/6 weeks, under no hyperbaric oxygen.

II. Radiotherapy under hyperbaric oxygen at 3 atmospheric pressure: Since 1963, a new transparent lucite pressure chamber was obtained. With reduction of oxygen pressure from 4 atmospheres to 3 and with the elimination of general anesthesia, a more conventional fractionation with 5 to 10 treatments given every other day or every other 2 days can be accomplished.

Glioblastoma multiforme. In the non-oxygen control group, a total tumor dose of 3600 rad/3 weeks (i.e., 400 rad per treatment, 3 treatments per week, giving in every other day for 3 weeks)

delivered to almost whole brain was found to be well tolerated. The observed mortality rate in this group of 30 patients of tissue proven glioblastoma followed the typical survival curve of glioblastoma reported in the literature. In the hyperbaric oxygen treated group, 12 patients are now available for evaluation. The procedure was well tolerated and the survival rate does not appear to be worse than the non-oxygen control group. Only one convulsion occurred over 200 treatments. The incidence is less than 1%.

Bilateral pulmonary metastases. Patients with bilateral pulmonary nodules secondary to radio-resistant tumor outside the lungs were selected. One lung is treated with 2000 rad/2 weeks (500 rad X 4 treatments) and the other lung is treated with the same dose except for having patient under hyperbaric oxygen during radiotherapy. It was observed in 2 patients that a slight increase of erythema and a slightly more regression of the nodules present in the side in which hyperbaric oxygen is added.

Palato-tonsillar and posterior tongue cancer. To date a total of 15 patients with advanced cancer of the palato-tonsillar and posterior lingual regions were treated under hyperbaric oxygen. The tumor dose is 3600 rad in 3 weeks

i.e.

600 rad tumor dose per treatment

given twice per week for 3 weeks. The response

in terms of initial tumor regression was very impressive. Two control groups are used

one with same unconventional fractionation and other with conventional fractionation

6000 rad/6 weeks. Again we observed a dose-reduction factor but less so than those treated with 2 or 3 fractions of massive dose.

The details of selection of patient material

scheme of randomization

initial response

and complication and survival curves will be discussed with illustrations and pictures.