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IMPROVEMENTS IN DESIGN OF A ^{90}Sr-^{90}Y PORTABLE BLOOD IRRADIATOR

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Suppression of lymphocyte levels in circulating blood following irradiation of the total body with low doses of ionizing radiation is well known. During the last decade, Cronkite and his group at Brookhaven have demonstrated that irradiation of blood in an exteriorized loop (extracorporeal irradiation of blood, ECIB) suppresses lymphocyte levels without damage to other body tissues. This group has shown that ECIB is an effective adjunct or alternative to drug therapy for treating some forms of leukemia.

Acceptance times of skin allografts have been extended by ECIB and several groups around the world are evaluating the technique for its applicability for immunosuppression relative to renal allografts. The most extensive summary of experience with human patients comes from Weeke and collaborators in Denmark (1). From their comparison of an ECIB treated group of 44

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patients with a reference group of 56 patients, they report a significant reduction in early rejection episodes and a significantly higher frequency of six-month renal graft survival in the ECIB treated group.

Most treatments of both experimental animals and humans have been accomplished by shunting blood through large fixed equipment such as ^{60}Co, ^{137}Cs or X-ray sources, thereby necessitating specialized facilities. With the relatively long treatment regimes required, this severely limits the numbers of patients who can receive treatment and requires the inconvenience and expense of hospitalization. A small inexpensive portable irradiator is needed for the above reasons and also to permit chronic exposures of patients prior to and subsequent to kidney transplant. This report describes an initial approach to supplying a portable blood irradiator.

Parametric calculations of dose rates to blood and surrounding tissue from photon and beta emitting isotopes indicated the desirability of photons in the 10 to 50 keV range or betas having maximum energies of 0.5 to 1 MeV. While low output irradiators using isotopes with emissions in these ranges were constructed and tested, limited availability of such isotopes forces the use of alternatives and ^{90}Sr-^{90}Y was chosen for the source material for a higher intensity unit. While the beta particles deliver an excellent dose to blood and are readily shielded from surrounding tissue, the bremsstrahlung radiation induced by the energetic ^{90}Y betas necessitates substantial shielding to reduce the external dose rate to acceptable levels.

Other groups using ^{90}Sr-^{90}Y for portable irradiators have spread the source material over a distance of several inches along the tube through which blood flows, in some instances passing the blood in multiple passes through the radiation field. Such elongation of the source area necessitates either a larger mass of shielding or produces an excessive external dose rate.

Using the computer program BETBLUD (2), dose to blood from a 1 Ci/cm^2 ^{90}Sr-^{90}Y source distributed along a 1 cm length surrounding a 0.133 cm radius blood tube was calculated to produce slightly over 20 rad per transit dose.

On the basis of these calculations, an irradiator has been constructed using as an outer shield a high density tungsten alloy 6.3 cm diameter, 5 cm long. Square corners were removed to minimize weight. The shielding piece was split and each half endmilled to produce a 2 mm radius groove. A 1 cm section in the mid-region was further milled to 3.2 mm to receive in each half inserts of 20 mg ^{90}Sr-^{90}Y fluoride bonded together by an SiO_2 preparation. Following insertion of the source material into the 1 cm long groove, a 0.25 mm aluminum foil containment layer was placed over each half and fastened in place by light beads of epoxy resin placed sufficiently distant from the source material to preclude resin contacting the source area.

Weight of the unit is 2140 g. Preliminary data from thermoluminescent dosimetry (TLD's) indicate that external surface dose rates slightly exceed the design dose rates of 50 m rem/hr. Efforts are underway to further improve the shield design by removing the low energy component of scattered radiation and X-rays from the surface flux. This effort should bring the measured dose rate into agreement with the design criteria.

Dosage to circulating blood is now being evaluated using the Fricke dosimeter. End pieces to serve as light shielding and prevent distortion of the blood tubing will be installed prior to testing in animals.

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(1) E. Weeke and S. F. Sorensen. Transplantation Proceedings. Vol. III, pp. 387-390, 1971.

(2). D. N. Slatkin and J. S. Robertson. Rad. Res. 44, pp. 846-854, 1970.

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