PRELIMINARY NOTE

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# Beta Radiation of Circulating Blood by an Implanted Shielded $Y^{90}$ Source, A Preliminary Report of Technique

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Several reports have appeared describing extracorporeal ionizing radiation of circulating blood of mammals (1-4). Because extracorporealization demands immobilization of the subject, precluding chronic irradiation, an attempt was made to irradiate only the circulating blood by replacing a portion of a large artery with a plastic graft. Around this graft was placed a metal shield containing commercially obtained $Y^{90}$ ceramic beads shielded in all directions excepting through the graft wall into the blood.

## TECHNIQUE

With 13-15 kg dogs under general anesthesia, the abdominal aorta is exposed below the renal arteries and a 6 cm section resected. This is replaced by a 6 cm length of 14 mm flexible woven "teflon" graft, using standard surgical technique.

After blood pressure is reestablished within the graft, the shield (shown in Fig. 1) is slipped over the graft. Twenty-five $Y^{90}$ ceramic beads (approximately 1.2 mm diameter) are glued (with a quick setting epoxy), just before placement in the animal, into a groove at the crest of a longitudinal ridge of acrylic adhering to the inside wall of the stainless steel tubing opposite the opening. This ridge indents the graft, increasing the solid angle of blood exposed to the beta source.

The shield is constructed from a piece of standard stainless steel tubing from which a longitudinal section wide enough to allow placement over the graft is removed opposite the row of beads. The I.D. is 10 mm and the wall thickness 1.2 mm, just sufficient to absorb the maximum beta of $Y^{90}$ (226 mev). (See Fig. 1). All adjacent tissue radiation is from bremsstrahlung originating in the shield wall with lesser amounts originating in plastic and blood. If this became a problem with extremely large amounts of beta emitter it could be minimized by

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constructing the shield of low Z material. A thin silver cover is designed to snap over the shield to cover the opening opposite the source to absorb any high energy beta unabsorbed by blood. Before surgical placement, the entire shield and $Y^{90}$ beads are subjected to standard autoclaving.

## RESULTS

In the two animals in which this final technique was applied 65 mc of $Y^{90}$ was implanted. No anticoagulant was used. The postoperative course was uneventful. Femoral artery pulses remained good. After surgical recovery the dogs behaved normally. In the first dog subjected to this technique, the arterial graft used was too narrow and did not enlarge under pressure to surround the beads. As a consequence, the solid angle of blood presented to the beads was quite small. This animal's blood probably received less than 1,000 rads. The circulating blood of the second animal (estimate one liter) was subjected to approximately 3,000 rads. The absorbed dose is estimated based on the assumption that 25 per cent of the total emission of the $Y^{90}$ beads is absorbed by circulating blood. This exposure will have been made during numerous passages of any particular blood element through the shield. The radiation experienced by any such element will be inversely proportional to the total blood volume if other factors remain constant. Absorption of 25 per cent is a crude estimate based upon our understanding of the geometry of the blood relative to the source. This cannot be predicted precisely. In this final animal the absolute peripheral lymphocyte count remained below 2,000 per $mm^3$ between 1 and 10 days, and subsequently slowly returned to approximately 5,000 at time of sacrifice. No such response was seen in the first animal.

Thirty-five days postop both animals were sacrificed. For $Y^{90}$ this represented approximately 13 half-lives. No adjacent tissue reaction was seen. The opened

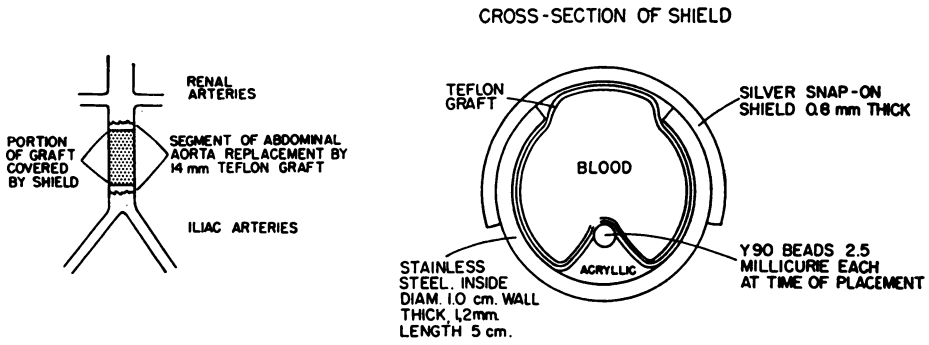


**Fig. 1: The location of the shield on the abdominal aorta below the renal arteries. The nonliving graft is necessary because the arterial wall itself would be destroyed by only a short exposure to the $Y^{90}$ beads. The cross sectional view of the shield indicates the relationship of the $Y^{90}$ bead and the arterial graft. The 1.2 mm of stainless steel plus the acrylic under the bead provide sufficient mass to completely absorb even the 2.2 mev beta particle of $Y^{90}$. The silver cover is snapped over the shield opening to prevent the emergence of any radiation completely traversing the graft.**

graft from the final animal is shown in Fig. 2. There is a thin clot in the "gutters" adjacent to the region indented by the beads. The region of graft immediately adjacent to the beads and which received the most radiation is clear of clot.

## DISCUSSION

The choice of an arterial graft as a site for an implanted beta source is governed by the well-standardized surgical technique for introducing such grafts and the ease with which clotting can be avoided. Radiation through a living vessel wall is impossible. An alternative would be to construct a tubular shield which could be placed within an artery or to suspend the source in the fluid stream inside an open framework which will keep the source sufficiently far from any vessel wall that the maximum energy beta rays can not pass out of the blood. Although such intra-arterial sources could probably be devised, it was felt that considerable development would be required simply to assure such a shield would be tolerated by the vessel and would remain in place unclotted.

When the general approach to irradiating a living fluid stream was undertaken as described here, the intention at first was to divert the flow of the thoracic duct through a catheter exposed to an implanted shielded beta source. After failing to cannulate this delicate structure in four dogs this was given up. If such a shielded source could be placed entirely within the thoracic duct of larger ani-

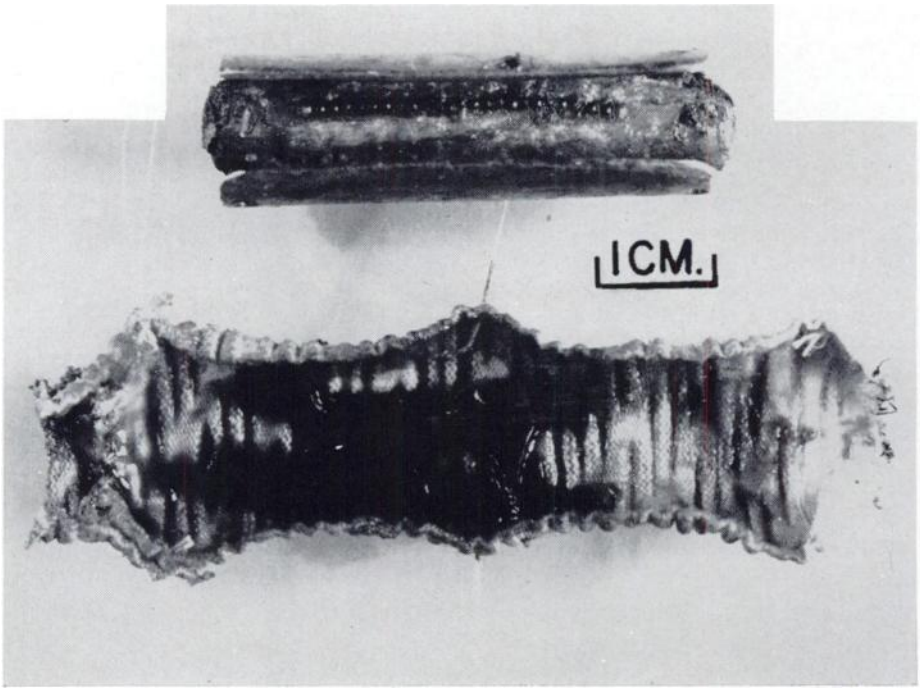


**Fig. 2: Photograph of the plastic graft and shield after sacrifice of the second radiated animal described here five weeks after implantation. No gross local tissue reaction was seen adjacent to the shield in the retroperitoneal space.**

mals, high level chronic irradiation of only lymphocytes should be possible. More chronic irradiation would be possible from longer lived beta emitters such as $P^{32}$ and $Sr^{90}$.

## SUMMARY

1. A technique is described in which chronic beta irradiation from $Y^{90}$ of circulating blood is achieved *in vivo*.

2. Utilizing standard surgical techniques, a segment of the lower abdominal aorta of dogs is replaced by a flexible teflon arterial graft. A shield containing $Y^{90}$ beads is placed about the graft. Irradiation of blood is achieved through the graft material.

3. After placement of the graft and shielded radioactive source, the animal's activities are not restricted.

4. Two dogs subjected to this final form of the technique tolerated the procedure well.

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