Treatment of Inoperable Primary Pancreatic and Liver Cancer by the Intra-Arterial Administration of Radioactive Isotopes (Y^{90} Radiating Microspheres) *

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INOPERABLE CANCERS of the pancreas and those of the liver have, for the most part, resisted efforts at control. Most modalities, including external radiation and chemotherapy have shown little success in controlling these neoplasms. This report describes experience with patients, suffering from inoperable primary pancreatic and liver cancer, who were treated by the intra-arterial administration of a radioactive isotope in the form of radiating microspheres,** to which has been attached yttrium 90 (Y^{90}).

Methods and Technics

The technic for administering the isotope consists in cannulating the femoral artery and inserting a polyethylene catheter retrograde through the aorta to the level of the coeliac axis. With tourniquets on both thighs, the solution in which the radiating microspheres are suspended is injected. The catheter is then withdrawn and pressure upon the femoral artery suffices to control any bleeding.

Photoscans of the abdomen were obtained using the isotope ytterbium 169 (Yb^{169}) as a suitable gamma emitter attached to the microspheres and scanning with the Baird Atomic Medical Scanner. The distribution of the administered radioactive microspheres throughout the abdominal cavity is shown in Figure 1.

In some patients a Dotter-Lukas catheter was inserted through the femoral artery to the level of the celiac axis and the radioactive isotopes were administered through it and delivered to a point proximal to the balloon in the catheter.

In several patients suffering from cancer of the liver, a catheter was inserted through the gastroepiploic artery, brought to the outside, and threaded retrograde to the hepatic artery, permitting irradiation throughout the liver. This technic was described by Miller [17] (Fig. 2).

Microspheres represent a new approach in internal irradiation, whereby a radioactive isotope is attached to an inert carrier.[15] The spheres are ceramic, completely inert chemically and physiologically, measuring from 1 to 200 microns in diameter. They have been produced in uniform size; those utilized in these experiments were 50 ± 10 microns in diameter. The spheres have an absolute density of 3.0 Gm./cm.^{3} and a bulk of 2.0 Gm./cm.^{3}, depending upon their size. They have a melting point in excess of 1,500° C. and are insoluble in organic and inorganic solvents. When administered into a given arterial system the microspheres are carried to the tiny arterioles where they are trapped and permanently lodged.

Yttrium 90 is a radioactive element with rather good radiologic characteristics for

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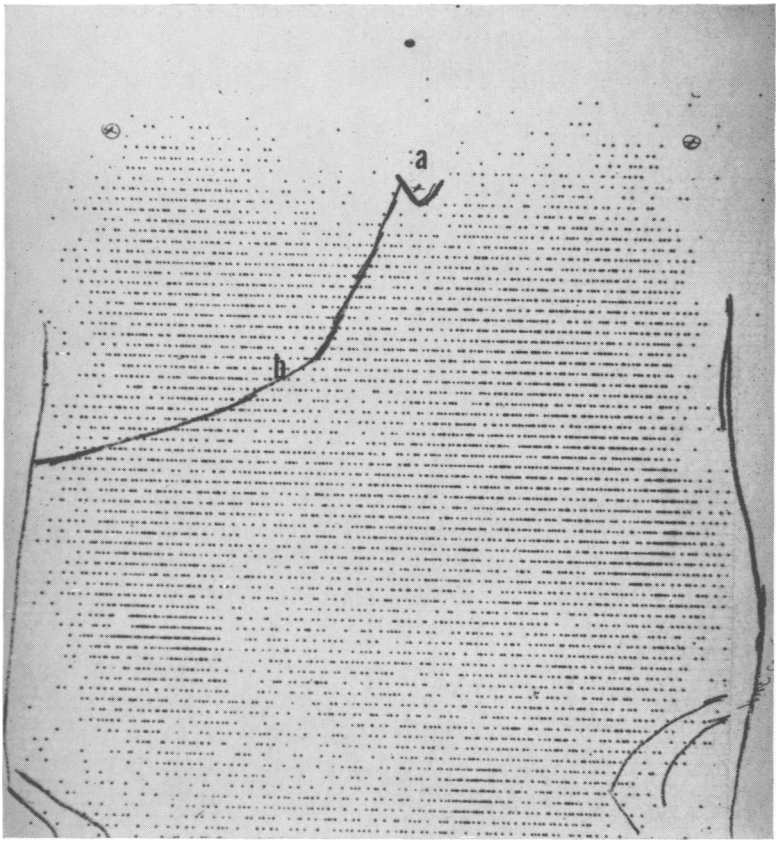

FIG. 1. Photoscan of abdomen in patient who received radiating microspheres to which are attached Yb^{169}. Catheter was inserted into aorta at level of celiac axis. Note uniform distribution of radiation source. Entire abdomen, including liver and spleen, has retained administered microspheres. (a) xiphoid process. (b) right costal margin.

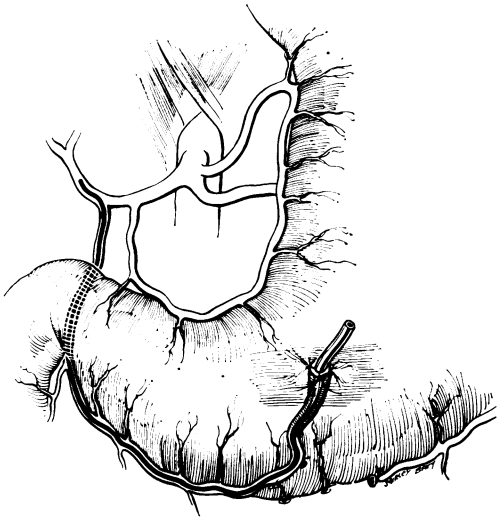

FIG. 2. Drawing demonstrating technic of inserting a catheter into hepatic artery via gastroepiploic artery, and then brought to the outside to allow ligation of gastroepiploic artery when catheter is withdrawn. (From T. R. Miller,[17] courtesy of Arch. Surg.)

systemic clinical therapeutic application and was used for therapy exclusively in this report. The isotope is a 2.18 mev pure beta emitter with a half life of 61 hours; it has a maximum penetration of about 8 mm. in tissue, therefore limiting irradiation to within the vicinity of the microspheres. The bond of yttrium to the microspheres is permanent, and the isotope will not "leach off" under the most severe conditions. Accordingly, this provides a means of administering, intra-arterially, radioactive sources which remain completely localized to the site of administration; they will not be distributed throughout the venous system and will not reach the bone marrow. In no patient treated by the author was there ever any evidence of bone marrow depression.

The exact dosage in the tissues is difficult to calculate because it was impossible to

TABLE 1. *Patients with Primary Cancer of the Liver Treated with Intra-Arterial Y^{90} Microspheres Delivered into Aorta at Level of Celiac Axis*

Patient	Age Sex	Extent of Cancer	Y^{90} Microspheres Dose & Date	Treatment Post Intra-Arterial Y^{90} Microspheres	Response	Remarks
M. C.	18 M	Localized to liver (hepatoma)	100 mc. (7/28/61)	25 mc. I^{131} Rose Bengal I.V. (9/7/61) 75 mc. Y^{90} interstitially (11/20/65)	Fairly comfortable with extensive hepatoma for 1½ yr. by combined isotope therapy	Died 8/22/62. Ascites controlled. Developed extensive collateral circulation with numerous superficial veins
G. R.	39 F	Generalized abdominal. Huge hepatoma	150 mc. (5/11/62)		Good palliation with liver shrinkage; 3-mo. reactivation resulting in death	Died 8/8/62
B. S.	51 F	Liver and regional lymph nodes	20 mc. (7/13/61) 25 mc. (9/7/61)		Excellent palliation; relief of all symptoms for 2 mo. Reactivation of cancer with jaundice. No response to second treatment	Died 10/1/61 in coma
B. F.	51 M	Hepatoma involving both lobes of liver	60 mc. (3/18/64)	Methotrexate, I.A. 50 mg. in 4 days	Excellent response; complete relief of all symptoms; shrinkage of liver, and decrease in cancer shown by hepatic photoscan. Remains well 5 mo. later	Isotopes given directly into hepatic artery via catheter threaded thru gastroepiploic artery

determine the exact distribution of the administered isotope. However it has been calculated that 0.6 mc. of Y^{90} will deliver 1,000 rads beta to a 100 Gm. spherical organ. Therefore, considering the large doses administered to the patients in this series, the lesions in either the pancreas or liver received between 10 to 20,000 rads beta. Calculating the dose on the basis of an even distribution of isotope throughout an organ and assuming a liver weight of 1,700 Gm., 100 mc. Y^{90} will deliver 11,000 rads beta to the liver.[15] These values do not allow for the variation in distribution of the isotope within the liver and within the cancer. Experiments are in progress to ascertain the validity of these calculations in the determination of the quantity of isotope within the neoplasm.

Results

The patients are analyzed according to the site of their primary cancer (Tables 1, 2).

Primary Liver Cancer

Patients with primary cancer of the liver demonstrated some beneficial effect from the intra-arterial administration of the radioactive yttrium microspheres (Table 1).

One patient (M. C.), an 18-year-old boy, had an extremely extensive primary hepatoma localized to the liver, which almost completely filled his abdominal cavity. Following the intra-arterial administration of 100 mc. Y^{90} there was shrinkage in the size of the liver to about three fourths its original size. The patient enjoyed a sense of well being with relief of pain which lasted for 2 months. The liver gradually increased in size, producing a feeling of distension, most marked postprandially. Despite this, there was control of the ascites which had been most troublesome prior to treatment. He was treated with 25 mc. I^{131} Rose Bengal, according to a technic described by the author;[4] two months later he was treated by the interstitial administration of

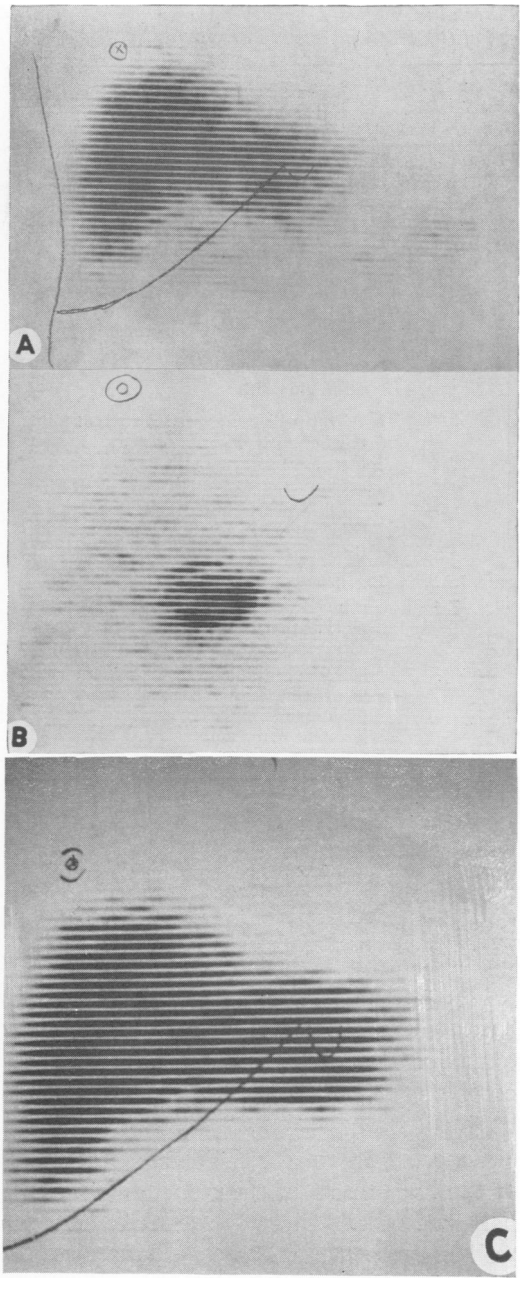

FIG. 3. **A.** Hepatic photoscan (I^{131} Rose Bengal) in patient B. F., demonstrating a large metastatic cancer in lower portion of liver and smaller ones scattered throughout left lobe. **B.** Hepatic photoscan after administration of Yb^{169} microspheres into hepatic artery. Note concentration of isotope in region of larger metastatic deposit.

C. Hepatic photoscan (I^{131} Rose Bengal), 4 months later. Note improvement, with shrinkage in size of metastases.

75 mc. Y^{90} microspheres. This combined isotopic therapy produced moderate palliation with visible evidence of shrinkage in size and extent of the cancer for 1½ years. It is believed that this combination resulted in a prolongation of life with palliation, although it could not cure the primary hepatoma. His preterminal period was marked by the extensive development of superficial veins.

The second patient (G. R.), a 39-year-old woman, suffered from a huge hepatoma and generalized abdominal metastases. She was treated by the intra-arterial administration of 150 mc. Y^{90} microspheres with the following response: marked shrinkage in the size of the liver, a sense of well being, improved appetite and diminution in pain. The palliation lasted for 3 months, after which a sudden regrowth of the cancer occurred and she died shortly thereafter.

The third patient (B. S.), a 51-year-old woman who had a primary liver cancer with metastases to the regional lymph nodes, was treated with 20 mc. Y^{90} microspheres intra-arterially. All symptoms were relieved for 2 months, followed by a reactivation of the cancer growth with severe jaundice. A second dose of 25 mc. Y^{90} given intra-arterially had no effect; she died 3 months after the first course of therapy.

A fourth patient (B. F.), a 51-year-old man with a primary hepatoma, in whom a catheter was inserted retrograde through the gastroepiploic artery into the hepatic artery, and who was treated with 60 mc. Y^{90} microspheres plus 50 mg. methotrexate, enjoyed complete relief of all symptoms, wtih shrinkage of his hepatic cancer to a point where it could not be palpated. Hepatic photoscans before treatment and 4 months later showed the evident improvement (Fig. 3). The patient remains well 5 months after therapy.

TABLE 2. *Patients with Primary Cancer of the Pancreas Treated with Intra-Arterial Y^{90} Microspheres Delivered into Aorta at Level of Celiac Axis*

Patient	Age Sex	Extent of Cancer	Y^{90} Microspheres Dose & Date	Concommitant Treatment	Treatment Post Intra-arterial Y^{90} Microspheres	Response	Remarks
A. F.	65 M	To liver producing ascites	120 mc. (4/16/63) 100 mc. (5/7/63)	4/16/63, nitrogen mustard, 20 mg.	None	Markedly improved, subsidence of ascites. Remains well 1 yr. later	Only complaint—weakness
G. H.	62 F	To liver producing ascites	50 mc. (2/4/63)	None	Hydrothorax thoracentesis 2/4/63. 50 mc.Y^{90} interstitially 2/13/63	Questionable palliation. Control of ascites	Died 6/13/63
H. H.	59 F	"Argentaffin tumor" of pancreas. To peritoneum and liver	15 mc. (7/10/62) 30 mc. (9/30/63)	20 mc.$CrP^{32}O_4$ intra-abdominally 7/10/62	None	Remains well and asymptomatic 20 mo. later	Good response with relatively small dose. Carcinoid syndrome controlled by 5-Fluorotryptophan
A. L.	61 F	To liver and peritoneum	125 mc. (8/1/63)	10 mc.$CrP^{32}O_4$ intra-abdominally 8/1/63	None	Relief of all symptoms. Shrinkage of mass. Remains well 7 mo. later	Developed abdominal pain and weakness 5 mo. later
G. M.	55 M	To liver producing ascites	100 mc. (5/23/63) 45 mc. (9/11/63)	None	None	Good symptomatic improvement. No further ascites	6 mo. later developed dissemination of the cancer. Died 4/30/64
H. S.	65 M	Pancreas	125 mc. (9/19/63)	None	None	Paresis of right foot. Remains well. Weight gain. Asymptomatic 10 mo. Excellent response	Hepatitis 2/15/64 with complete recovery

TABLE 3. *Blood Count and Certain Liver Function Tests in Patients with Primary Cancer of the Liver Treated by Intra-Arterial Y^{90} Microspheres*

Patient	Age Sex	Date	Hemoglobin (Gm./100 cc.)	White Blood Count (per mm.³)	Alkaline Phosphatase (S.J.R. units)	Bilirubin (mg./100 ml.)	Transaminase (SGOT-Beckman units)	Bromsulphalein (%)	Y^{90}-Date & Dose
M. C.	18	7/20/61	10.3	10,850	8.9	0.4 -30′	160	7.6	7/28/61
	M	10/ 2/61	9.1	10,350	15.1	0.3 -30′	154	7.0	100 mc.
		11/27/61	8.4	7,200	9.0	0.3 -30′	230	7.0	
G. R.	39	5/ 7/62	10.3	5,820	9.0	2.9 -30′	100	—	5/11/62
	F	5/14/62	10.3	4,680	4.0	3.0 -30′	105	—	150 mc.
		6/25/62	9.7	4,380	4.0	3.5 -30′	100	—	
B. S.	51	5/24/61	10.5	4,450	36.4	5.8 - 1′	170	—	7/13/61
	F					7.8 -30′			30 mc.;
		7/13/61	11.0	5,540	37.6	1.32- 1′	122	—	9/6/61
						7.2 -30′			25 mc.
		9/ 6/61	12.5	6,000	42.2	18.0 - 1′	193	—	
						27.5 -30′			
B. F.	51	1/16/64	14.3	9,100	7.74	0.35 Direct			
	M					0.35 Indirect			
						0.7 Total			60 mc.
		2/14/64		4,150					3/18/64 &
		3/ 5/64	14.7	9,600					
		3/19/64			4.0	0.7 Total	42 SGOT		Methotrexate
							55 SGPT		50 mg. total
		3/26/64			9.0	0.3 Total	70 SGOT		
							135 SGPT		
		5/13/64	14.2	6,600	16.0	0.14- 1′			
						0.3 -30′	63	3.2	
		7/23/64			17.1	8.2 -30′	460		
		8/ 1/64	13.5	6,350	39.8	11.9 -30′	124		

Primary Pancreatic Cancer

The patients with primary cancer of the pancreas treated by the intra-arterial administration of Y^{90} microspheres usually demonstrated a favorable response (Table 2).

Two patients (A. L., female, age 61 and G. M., male, age 55), enjoyed transient palliation for 5 and 6 months, respectively, followed by evidence of dissemination of their cancer; the latter expired 11 months after therapy.

Three patients remained well with apparent control of their cancers for prolonged periods. Patient 1 (A. F.), a 65-year-old man, remains well and asymptomatic 1 year after the intra-arterial administration of the Y^{90} microspheres; he received two doses spaced 3 weeks apart, the first 120 mc. and the second 100 mc. His ascites was completely controlled. Patient 2 (H. H.), a 59-year-old woman, had a primary carcinoid of the pancreas with metastases to the peritoneum and liver. She received two rather small doses of Y^{90} microspheres. The first course consisted of 15 mc.; the second, 2 months later, of 30 mc. At the time of the first dose, she also received 20 mc. of radioactive chromic phosphate intra-abdominally to help control the peritoneal implants. This patient remains well 20 months after therapy, at which time she developed symptoms of the carcinoid syndrome (flushing, diarrhea and weight loss), combatted by 5-Fluorotryptophan administered by Dr. Cyril Costello of St. Louis. Since carcinoid tumors are of relatively low-grade malignancy and behave differently from carcinoma of the pancreas, this case should be viewed separately. Patient 3 (H. S.), a 65-year-old man, who, on exploratory laparotomy was found to have extensive cancer localized to the pancreas, was treated with 125 mc. Y^{90} microspheres; he remains well and asymptomatic 10

TABLE 4. *Blood Count and Certain Liver Function Tests in Patients with Primary Cancer of the Pancreas Treated by Intra-Arterial Y^{90} Microspheres*

Patient	Age Sex	Date	Hemoglobin (Gm./100 cc.)	White Blood Count (per mm.³)	Alkaline Phosphatase (S.J.R. units)	Bilirubin (mg./100 ml.)	Transaminase (SGOT-Beckman units)	Bromsulphalein (%)	Y^{90}-Date & Dose
A. F.	65	4/14/63	12.1	5,900	12.0	10.5–30′	30	—	4/16/63
	M	4/25/63	12.1	9,500	9.0	11.0–30′	40	—	120 mc.;
		5/8/63	13.4	6,200	24.0	—	50	—	5/7/63
									100 mc.
									Total-220 mc.
G. H.	62	2/ 3/63	10.0	8,800	26.0	—	120	—	2/4/63
	F	2/ 5/63	11.5	8,750	28.0	—	125	—	50 mc.
		2/11/63	12.1	6,800	26.0	—	100	—	
H. H.	59	—	—	—	—	—	25	—	7/10/62
	F	7/10/62	12.1	5,790	6.0	—	30	—	15 mc.;
		7/17/62	11.5	9,300	—	—	25	—	9/30/63
									30 mc.
									Total- 45 mc.
A. L.	61	8/ 2/63	13.9	7,100	3.0	—	17	—	8/1/63
	F	8/28/63	12.2	6,000	—	—	—	—	125 mc.
G. M.	55	5/21/63	12.4	7,800	5.0	—	25	—	5/23/63
	M	5/29/63	11.0	2,820	8.0	—	35	—	100 mc.;
		10/22/63	13.0	10,400	4.0	—	20	—	9/11/63
									45 mc.
									Total-145 mc.
H. S.	65	2/15/64	12.1	13,750	37.8	4.6– 1′	500	—	9/19/63
	M					8.2–30′			125 mc.
		7/21/64	13.9	7,400	8.2		20		

months later. Five months after treatment he developed icterus and signs of liver disease which were diagnosed as hepatitis and from which he completely recovered. He developed a post-treatment paresis of the right leg, considered a complication of therapy to be discussed later in greater detail.

Of six patients treated, only one (G. H.) had questionable palliation and expired 4 months following therapy. This patient suffered further from metastases to the chest with hydrothorax. Here, treatment resulted in complete control of ascites and hydrothorax (a previously bothersome symptom) for the duration of her life.

Effects on the Blood Elements of Intra-Arterial Y^{90} Microspheres

The effects of intra-arterial Y^{90} microspheres upon certain of the blood constituents are shown in Tables 3 and 4. The former shows the effect on patients with primary cancer of the liver; it should be noted that no significant alteration can be attributed to this therapy.

Patient M. C. developed anemia in the course of therapy, not caused by the isotope administration. A moderate increase in level of serum alkaline phosphatase occurred, which later decreased to normal. As his disease progressed, the serum transaminase level gradually increased; a slight decrease was noted immediately after treatment. In patient G. R., the serum transaminase level increased slightly, whereas in patient B. S. it decreased after administration of the Y^{90} microspheres. Patient B. F. had an increase in the serum transaminase level after therapy, which persisted for 2 months.

The effects of isotope therapy upon patients with pancreatic cancer are shown in Table 4; there is no demonstrable effect

upon either the blood elements or chemical tests performed. The questionable increase in serum alkaline phosphatase and mild increase in serum transaminase, present in all patients immediately after therapy, usually reverted to decreased levels.

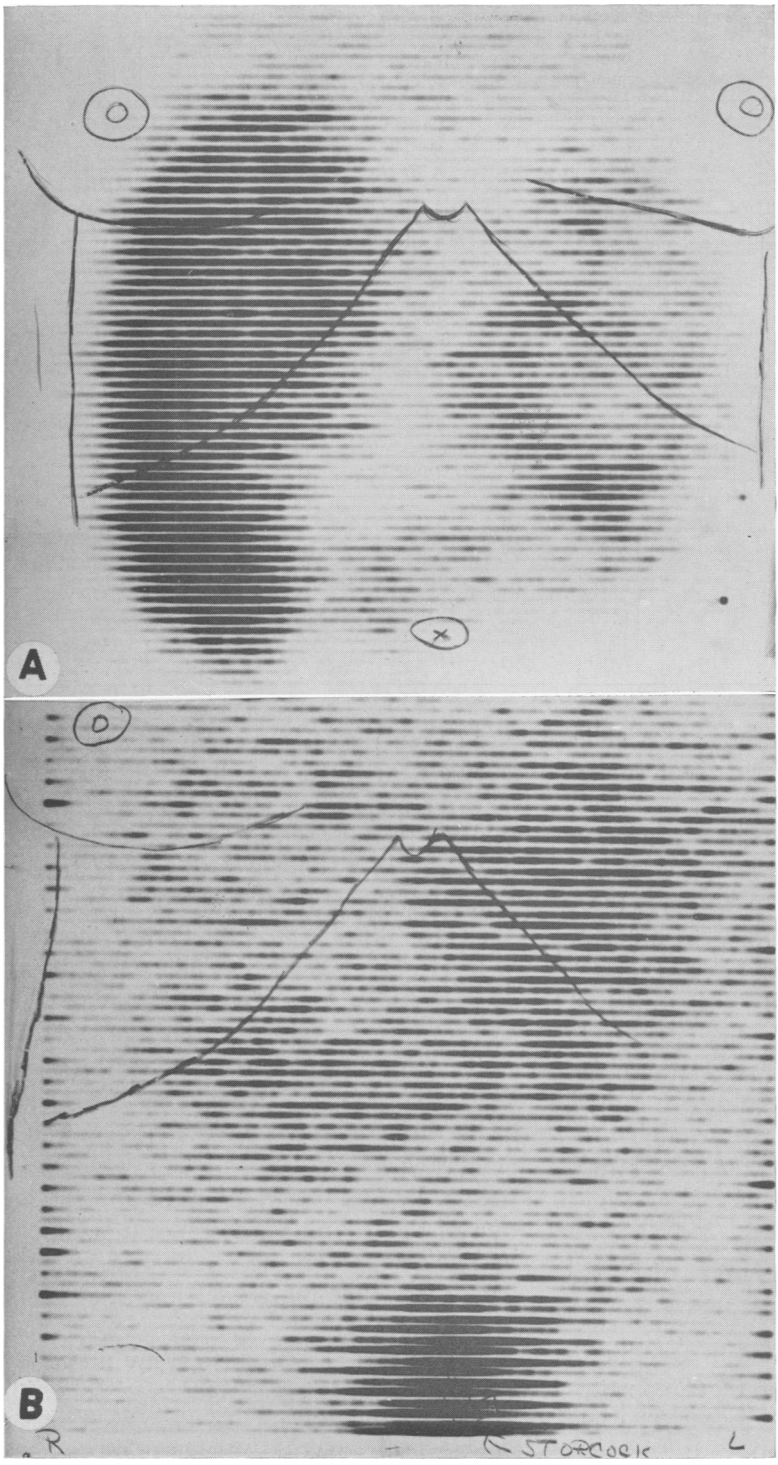

FIG. 4. **A.** Hepatic photoscan (I^{131} Rose Bengal), of patient with hepatomegalia and replacement of a large segment of her liver with metastatic melanoma. **B.** Photoscan after injecting Yb^{169} microspheres into hepatic artery. Note concentration of isotope in regions of liver occupied by cancer. The black region at bottom of photograph represents radioactive microspheres trapped in stopcock.

Complications

The only complication observed was paresis of the right leg in one patient, believed the result of either dislodgment of an atheromatous plaque or, possibly, penetration of the microspheres into the spinal arteries, thus affecting the spinal cord. Another patient, not reported in this series, had extensive intra-abdominal cancer, primary in the ovaries, and was treated by intra-arterial administration of radiating microspheres. Paraplegia followed and appeared to be subsiding at the time of death from cancer.

When the microspheres have been administered the patients usually have been lying on their back. Numerous small, petechial-like irradiation reaction sites involving the back and the buttock were produced, indicating a posterior distribution of the microspheres (Fig. 5). Inasmuch as the microspheres are heavier than neutral density, they would tend to gravitate to the most dependent position, here to the posterior.

Recently we have inserted the catheter with the patient supine; we then turned the patient on his abdomen and the microspheres were injected with the patient prone. Since the adoption of this method of administration there have been no complications.

Generally there has been no hematopoetic depression from this treatment and no great alteration in the hepatic function tests. There may be a slight, but transient, increase in the serum transaminase level, also observed by Perry and MacLean.[19]

The tourniquets should be tightly placed around the thighs, otherwise microspheres will be transported to the feet, producing pain in the plantar aspect. These painful sites last from 1 month to 6 weeks and gradually subside.

Discussion

The concept whereby a dose of irradiation can be delivered through the arterial system into a cancer is appealing. Should this be accomplished, it then will be possible to diffusely irradiate a cancer through multiple sources. In many cancers the blood supply is diminished and may be much less than that of the host organ. However in other cancers the nature of the blood supply is such as to deliver an increased quantity of microspheres throughout. Figure 4 represents an hepatic photoscan in a patient with metastatic cancer to the liver: *A.* is the I^{131} Rose Bengal photoscan, demonstrating metastases within the liver, and *B.* is the photoscan following the introduction into the hepatic artery of 500 microcuries radiating microspheres in the form of ytterbium 169 (Yb^{169}). It should be noted that those many regions in the liver occupied by the cancer show an increase in concentration of the radioactive source, demonstrating that the radiating microspheres had been delivered to the cancer itself.

Unfortunately our series is not large; only one patient with cancer of the liver survived for a prolonged period. In two patients, although there was an excellent response manifested by a shrinkage in the size of the liver and a feeling of well being, the response was transient. In both instances, the cancer was widespread, having metastasized to the liver, into the abdominal lymph nodes and to other intra-abdominal sites. The surviving patient demonstrated shrinkage of the liver and complete absence of symptoms, and the improvement was demonstrated on photoscan. He remains well and asymptomatic 5 months after therapy.

Patients with primary hepatic cancer generally have a short life expectancy as observed by Gustafsen [10]; average survival was 3.2 months. Berman's [5] patients survived an average of 4 months.

The present author reported the effects of irradiation from external sources and demonstrated that the liver will tolerate large doses.[1] This series of patients demonstrated

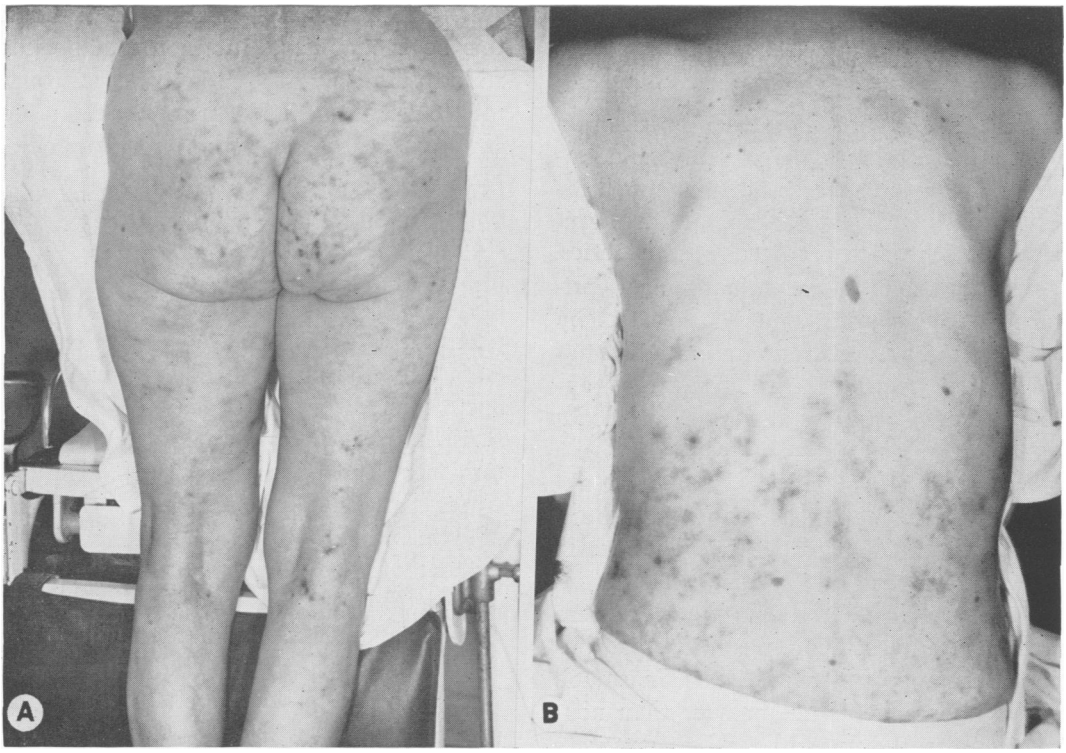

FIG. 5. Reactions in posterior skin after intra-arterial administration of Y^{90} microsphres in different patients. **A.** Reaction in this patient diffusely involved the buttock and lower extremities after administration of 100 mc. of Y^{90} microspheres. **B.** Reaction in this patient includes the lower back and, to a lesser extent, the buttock after administration of 100 mc. of Y^{90} microspheres.

that administration of intra-arterial isotopes into the hepatic artery may be well tolerated by the liver and, in some instances, may partially control the cancer to some degree.

Hahn [11] demonstrated that a dog liver will tolerate as much as 50,000 rads beta, when given an intravenous injection of radioactive colloidal gold. He further demonstrated that if the animal is either anemic or septic, biliary cirrhosis will be produced, and with much smaller doses of irradiation. These findings emphasize the need for the patient to be in as good physical and metabolic condition as is possible before treatment, and that the liver will tolerate large doses of irradiation.

Pancreatic cancer is one of the most malignant; it grows rapidly, metastasizes extensively and kills quickly. Attempts at treatment by means of external irradiation have been, for the most part, disappointing.

Richard [21] in 1922 treated two patients with external therapy who survived 10 and 20 months, respectively. Pack and McNeer [20] in 1938 treated 23 patients with pancreatic cancer, with an average survival of 8 months. Miller and Fuller [16] in 1958 reported 91 patients with inoperable pancreatic cancer, and the average survival was 6.6 months after the commencement of irradiation.

Billingsley, Bartholomew and Charles [6] in 1958 reported 52 patients with pancreatic cancer treated at the Mayo Clinic. The average survival after onset of symptoms was about 1 year for those treated with external therapy and 8 months for those not treated by external therapy. They concluded that the slight difference in survival was not significant and, therefore, irradiation therapy did not offer the patient

any appreciable chance for longevity. They further commented that no appreciable symptomatic improvement was evident and that many of the patients suffered discomfort as a result of irradiation.

Harper and Lathrop[12] devised an ingenious method for irradiating the pancreas for inoperable cancer. A thin polythylene catheter is coiled around the pancreas and radioactive iodine inserted into the catheter. Some beneficial response was noted but no increase in longevity.

Our six patients with primary cancer of the pancreas, treated by the intra-arterial administration of Y^{90} microspheres, have apparently benefited. The fact that one patient is alive without evidence of cancer 1 year after therapy, and one other remains well for 7 months, is interpreted as a beneficial response. One patient (G. M.) had improvement in symptoms for more than 6 months; reactivation of the cancer resulted in death 11 months after treatment. One patient (G. H.) with ascites and hydrothorax, who expired 4 months after therapy, showed slight palliation. Patient H. H., suffering from an "argentaffin tumor" arising in the pancreas and metastatic to the liver and peritoneum, cannot be considered in the same category as those with primary carcinoma of the pancreas, inasmuch as carcinoid is much less malignant than carcinoma; she remains well 20 months after treatment. The complete subsidence of ascites in two patients treated would focus upon the need for further study regarding this unexpected beneficial response.

Dogliotti[7] injected Y^{90} particles intra-arterially in the treatment of patients with renal cancer and inoperable cancer of the head and neck. Grady[8,9] and colleagues utilized large particles of Y^{90} oxide as a source for internal irradiation with encouraging results. Five of their 12 reported cases had metastatic cancer to the liver. MacLean and Perry,[19] and their group from Ancker Hospital, St. Paul, Minnesota, reported used radiating micropheres in treating experimental and human cancer with encouraging results.

Summary and Conclusions

A technic for delivering radiating microspheres internally to patients suffering from primary hepatic and pancreatic cancer has been described.

The intra-aortic administration of radiating microspheres at the level of the celiac axis results in the internal deposit of large quantities of radioactive sources, which irradiates cancer of the liver and pancreas with apparent effectiveness.

The technic described has been well tolerated; it is believed that some patients have enjoyed increased longevity, and a significant number have enjoyed palliation from this form of internal irradiation.

Complications are minimal. When given to patients in the prone position there have been no complications.

Further studies are being pursued to determine the exact distribution of the administered isotopes, the irradiation dose delivered to the cancer and the prolonged effect of this form of therapy on patients with inoperable cancer of the liver and pancreas.

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