Original Communications

Preliminary Clinical Experience with Intraoperative Radiotherapy

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Intraoperative radiotherapy is the term applied to the irradiation of unresectable tumors, partially resectable tumors, and regional lymph nodes with external beam radiation at the time of surgical exposure. Since only one treatment is given at the time of surgery, one should consider the intraoperative technique as "boost" therapy which may allow us to raise the conventional external beam dose to the tumor by 50 to 100 percent. At Howard University Hospital and Cancer Research Center, seven advanced-stage cancer patients have been treated since 1976 with single doses of electron beam irradiation in the range of 1,300 to 2,000 rad. The preliminary evaluation of these patients has shown no serious acute radiation reactions.

Intraoperative radiation therapy is a surgical-radiotherapeutic team approach to the management of unresectable or incompletely resectable neoplasms of the abdomen, thorax, cranial cavity, and subcutaneous tissues. In contrast to interstitial implants with radioisotopes, no radiation precautions are required after the patient leaves the operating room.

Historically, several authors have used intraoperative radiation therapy, but only in a few cases and only with low energy orthovoltage x-ray machines.[1-8] From the physical point of view, electron beams in the 6 to 15 MeV range are much superior. The credit for the recent interest in intraoperative radiotherapy belongs to Abe, who since 1967 at Kyoto University in Japan has treated more than 150 patients with encouraging results.[9-11] At Howard University Hospital and Cancer Research Center, the first integrated intraoperative radiation therapy facility in the United States is in use. This is a brief report on preliminary clinical experience in the first seven patients in that facility.

Materials and Methods

The Howard University Hospital intraoperative facility is a surgical theater which meets the radiation shielding criteria to accomodate a Varian 18 MeV linear accelerator (Figure 1). The Varian 18 MeV accelerator was chosen because it has electron beam capabilities of 6, 9, 12, 15, and 18 MeV electrons. This spectum gives good flexibility in controlling the depth of the tissue irradiated.

In all of our first seven cases, maximum tumor resection was attempted. As surgery provided direct visualization of the treatment regions (Figure 2), the specific field size and electron beam energy could be selected. Emphasis was placed on minimizing the dose beyond the tumor volume. All uninvolved structures were retracted out of the treatment beam, to reduce unwanted radiation effects (Figure 3). Another possibility, namely to clamp the arterial supply shortly before and during the postoperative radiotherapy,[12] was not used in these patients.

From November 1976 through September 1977, seven patients with advanced stage tumors, who would not have been candidates for conventional surgical or radiotherapeutic management, were treated in the Howard University intraoperative radiotherapy facility.

A dose of 1,300 to 2,000 rad, single fraction, 9 to 15 MeV electron beam irradiation was delivered through a 7.5 cm diameter treatment cone. While single doses are an acknowledged limitation of intraoperative radiotherapy, there is evidence that fewer fractions than used presently, eg, one fraction per week,[13] may be quite satisfactory. Radiosensitizers may offer an additional possibility to overcome the disadvantage of single-dose treatment.

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Table 1. Preliminary Clinical Experience With Advanced Stage Carcinoma Treated by Intraoperative Radiation Therapy

Patient	Age, Race, and Sex	Diagnosis	Surgery	Intraoperative Portal	Cone Size (cm)	Beam Energy	Dose (rad) Calculated at D max	Time after Treatment, Symptoms, and Survival
JR	70 Black Male	Moderately well differentiated squamous lung carcinoma	Thoracotomy	Right hilum	8.5	18 MeV D max 5.2 cm	1,500	22 days no side effects now gets XRT boost to mediastinum
JJ	62 Black Female	Poorly differentiated stomach adenoma	Exploratory laparotomy Biopsy partial omentectomy	Gastroesophagal junction	6	15 MeV D max 4.5 cm 18 MeV D max 5.2 cm	1,500 1,000	150 days progressive disease with weight loss and diarrhea
TF	67 Black Male	Primary hepato-cellular carcinoma	Exploratory laparotomy	Middle and left lobe of liver	10x10	10 MeV photons	1,500	44 days alive with disease
JS	66 Black Male	Stomach adenoma	Subtotal gastrectomy omentectomy gastrojejunostomy	Celiac nodes	5	15 MeV D max 4.5 cm	2,000	126 days monilial esophagitis weight loss
EC	60 Black Male	Cancer mid esophagus Cancer distal stomach with liver metastases	Thoracotomy and laparotomy	Celiac nodes Esophagus	7.5 7.5	12 MeV D max 3.7 cm 12 MeV D max 3.7 cm	1,500 2,000	14 days died with disease
DN	20 Black Male	Biliary duct malignant papilloma with early infiltrating carcinoma	Laparotomy with 'T' tube	Porta hepatis	5.5	18 MeV D max 5.2 cm	1,330 also received ext. beam boost of 3,800	310 days alive with improved weight and mildly elevated enzymes
AB	50 Black Male	Poorly differentiated squamous lung carcinoma	Thoracotomy and lobectomy	Right hilum	7.5	9 MeV D max 2.7 cm	1,500	8 days asymptomatic, will get mediastinum boost

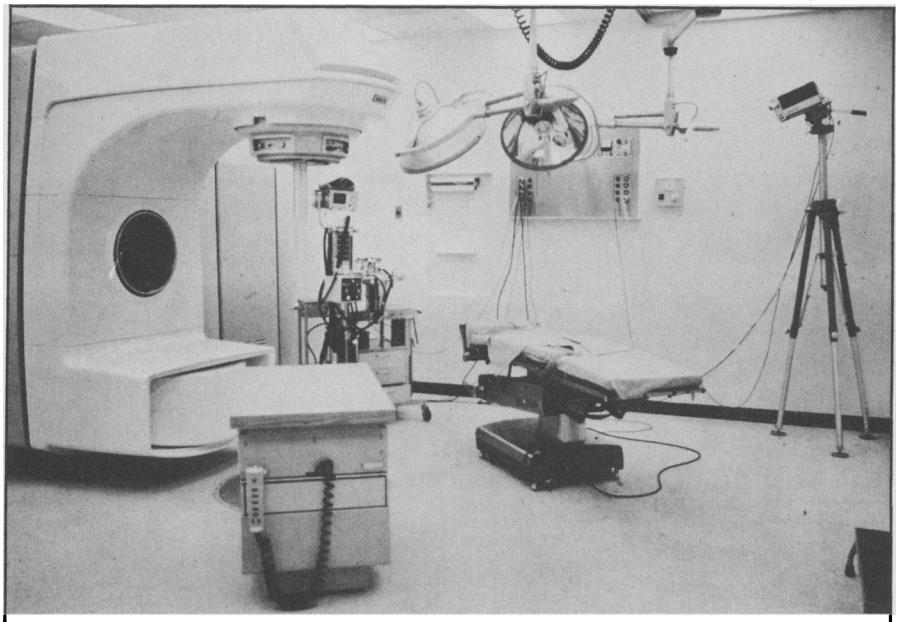

Figure 1. The Howard University Intraoperative Radiation Therapy Facility.

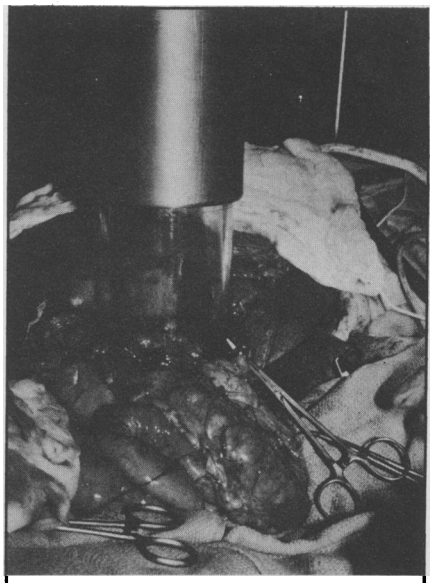

Figure 3. Treatment cone positioned to irradiate celiac nodes in carcinoma of the stomach. Note the retraction of sensitive bowel from the treatment field.

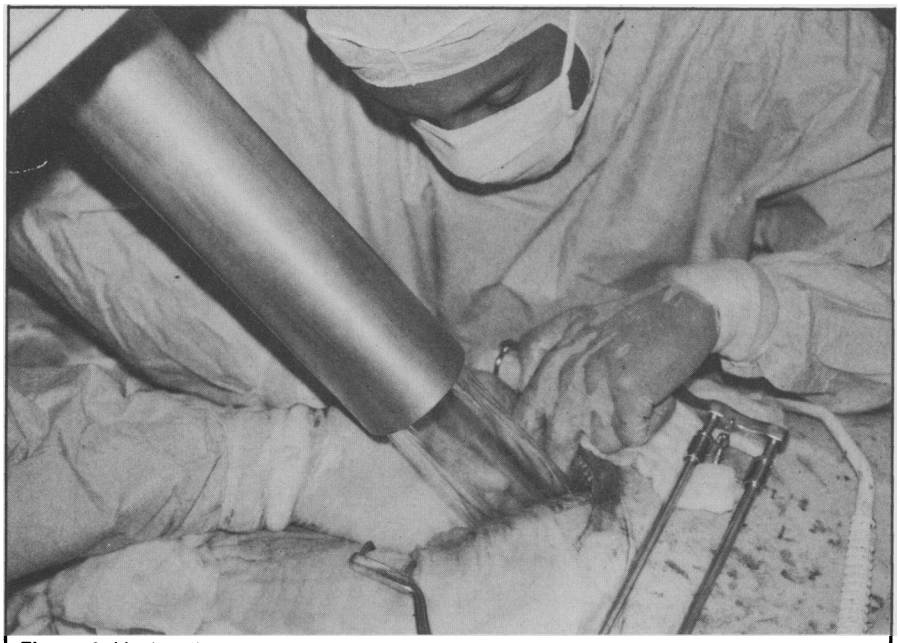

Figure 2. Under direct surgical exposure, the radiotherapist positions the specially developed lucite treatment cone over the area to be irradiated.

Results

Our follow-up of the seven patients ranged at the time of the presentation of this paper from one to twelve months. The results are summarized in Table 1. One patient, with separate primary tumors of the mid esophagus and distal stomach as well as massive liver metastases, died three weeks post treatment. Of the surviving patients, two have gastric carcinoma, two squamous cell carcinoma of the lung, one biliary duct carcinoma, and one a primary hepatocellular carcinoma.

The clinically assessable acute radiation reactions have been minimal. The only side reactions occurred in the two patients with gastric carcinoma. One developed candidal esophagitis and the other severe diarrhea approximately five months post treatment.

Discussion

In seven patients, intraoperative radiation for advanced intra-abdominal and intrathoracic neoplasm with doses of 1,300 to 2,000 rad did not result in serious acute radiation reactions. It is too early to assess late reactions, local control, and survival. However, the absence of significant acute complications with these dose levels is encouraging.

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