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PRELIMINARY EXPERIENCE WITH PERMANENT INTERSTITIAL IMPLANTS USING CHROMIUM 51 SOURCES*

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AT THE 1958 meeting of the American Radium Society, Myers[1,2] described the possible application of radioactive chromium 51 gamma ray sources for interstitial radiation therapy and compared the properties of these sources with the physical properties of a number of other isotopes. Recently, Henschke, Lawrence and co-workers[3,4] have reviewed the experience using permanent interstitial implants of several long-lived isotopes. Chromium 51 has a physical half-life of 27 days and a decay scheme as shown in Figure 1. It decays to vanadium 51 with the emission of a 323 kev. gamma ray in approximately 10 per cent of the time, and with the emission of soft x rays of less than 10 kilovolts. These soft x rays are almost completely absorbed by the chromium source itself. The decay scheme shows that no beta particles are emitted, making this isotope a desirable one for interstitial implantation. The $T_{\frac{1}{2}}$ is 0.18 r per hour at 1 cm. from a 1 mc source.[6] Myers[2] described the fabrication of several sources of different sizes. Our method of fabricating sources is slightly different and was suggested by Mr. Gene Asai of the United States Bureau of Mines.

MATERIAL AND METHOD

Highly pure chromium wire is drawn to proper diameter by passing the wire through a heated die which is brought to a temperature of 350°C. At this temperature, chromium may be drawn to proper sizes quite easily and may also be sheared and cut very accurately to proper length. The highly pure, nonradioactive chromium wire was drawn to the diameter of 0.031 inches by the United States Bureau of Mines. In our laboratory we use a special jig and shearing device in a heated oven to shear cylinders 2.5 mm. long from this wire. These sources are then loaded into aluminum cartridges supplied with the implantation gun, which is a modification of the gun described by Holt, Sinclair and Smithers.[5] This gun is commercially available and is shown in Figure 2. Also shown is the stainless steel sterilization container. Activation of these sources was carried out by the Argonne National Laboratory in the research reactor CP-5.

The source strength that proved most useful was between 4 and 6 mc per seed. Activation took 2 or 3 days. Following activation, these seeds were calibrated by means of Lauritsen quartz-fiber electroscope and compared with a radium standard. A second source was dissolved in strong acid and an aliquot of chromium solution was counted for activity and compared with a liquid standard. The

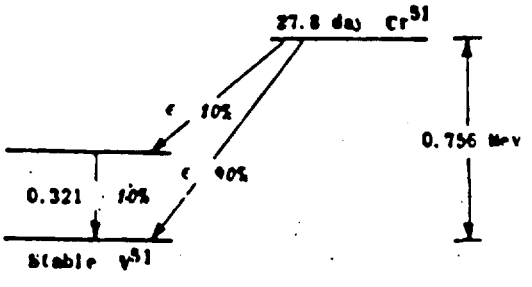

FIG. 1. Decay scheme of radioactive chromium 51.[7]

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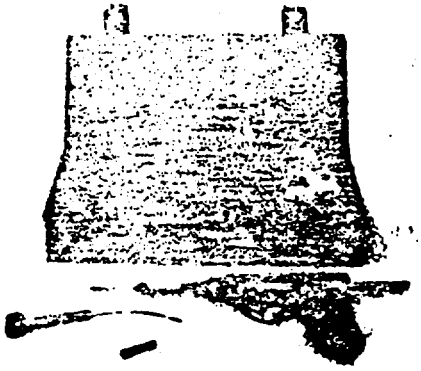

FIG. 2. Implantation gun showing aluminum cartridge, straight and curved needles and stainless steel sterilizing container.

FIG. 3. Roentgenogram showing the placement of the seeds.

two methods of calibration of the sources compared favorably, there being differences of less than 10 per cent between them.

Our first permanent chromium implant was made in a patient with metastases to the presacral area following an abdominal perineal resection for squamous cell carcinoma of the anus. The carcinoma was 6 cm. in diameter and the chromium sources were implanted percutaneously through the perineum. Long spinal 18 gauge needles were positioned throughout the tumor and their positions were roentgenographed. Following adjustment of the position of the needles, the lesion was implanted sequentially by removing the spinal needles and implanting the needle track with chromium seeds using the implantation gun. One chromium

TABLE I

FAVORABLE RESPONSE

Patient	Diagnosis	Previous Treatment	No. of Chromium Seeds and Activity	Calculated Dose	Comments
Q.D.	Carcinoma of anus	Surgery	60–3.55 mc	5,500 rads	7.5 years without recurrence
C.S.	Carcinoma of cervix, recurrent	Roentgen therapy and radium	57–4.00 mc	5,000 rads	Abdominal implant. Fistula in bladder 2 years after implant
E.D.	Carcinoma of breast	Roentgen therapy	10–3.00 mc	4,600 rads	Recurrence at edge of implant 1.5 years
M.V.	Squamous cell carcinoma of base of tongue	Roentgen therapy	5–1.15 mc	5,000 rads	Implant in metastatic lymph node. Excellent response. No tumor in lymph node at autopsy
A.N.	Carcinoma of pyriform sinus	Surgery and roentgen therapy	9–1.44 mc 3–1.50 mc	9,000 rads	Treatment of recurrence about tracheotomy stoma. No sinus
R.K.	Squamous cell carcinoma of palate, anterior pillar, and lower tongue	Roentgen therapy	17–4.50 mc	6,000 rads	Excellent local result, recurrence adjacent to implant
W.Z.	Neck metastases, squamous cell carcinoma	Roentgen and electron therapy	22–4.00 mc 14–3.60 mc 21–4.50 mc	6,000 to 6,500 rads	All lesions responded dramatically to implants
A.K.	Squamous cell carcinoma of cervix with vaginal recurrence	Roentgen therapy, radium applications and radium implants	22–4.00 mc 14–4.00 mc	5,000 to 5,000 rads	1 cm. ulcer 3 months after implant. Good local control
M.S.	Squamous cell carcinoma of tongue	Roentgen therapy	3–2.70 mc	6,000 rads	No recurrence at 6 months

TABLE II

GOOD RESPONSE

Patient	Diagnosis	Previous Treatment	No. of Chromium Seeds and Activity	Calculated Dose	Comments
J.F.	Squamous cell carcinoma of posterior tongue	Roentgen therapy	14 @ 10 mc	6,000 rads	Good response in the tongue for 7 months. Lymph node metastases
O.O.	Squamous cell carcinoma of larynx	Roentgen therapy and surgery	41 @ 1.50 mc	[illegible] rads	Excellent response in neck metastases for 4 months
G.P.	Carcinoma of oral pharynx	Roentgen therapy	13 @ 4.80 mc	6,800 rads	Autopsy revealed fibrosis and necrosis in the region of the implant. Patient died of distant metastases
E.C.	Carcinoma of cervix with pelvic metastases	Roentgen therapy and radium	22 @ 3.90 mc	5,000 rads	Good response of pelvic mass 1 months after implant
R.C.	Carcinoma of breast with skin metastases	Surgery and roentgen therapy	13 @ 4.50 mc	6,[illegible] rads	New lesions adjacent to implant 1 months following. Treated area shows no recurrence
D.K.	Carcinoma of larynx	Roentgen therapy and surgery	14 @ 2.85 mc	4,000 rads	Marked decrease in size of neck metastases
L.M.	Squamous cell carcinoma of penis with lymph node metastases	Roentgen therapy	15 @ 2.20 mc 51 @ 4.80 mc	5,500 to 6,000 rads	Marked shrinkage of lymph node metastases. Penile lesion showed small 1 cm. ulceration.
C.D.	Squamous cell carcinoma of anus	Surgery	10 @ 4.50 mc	5,000 rads	No palpable recurrence 6 months after implant
J.A.	Adenocarcinoma of rectum	Surgery and roentgen therapy	[illegible]	[illegible],?00 rads	Good pain relief and decrease of the tumor size for 3 months

source or seed was placed in each cubic centimeter of the tumor (Fig. 3). Sixty seeds, each 3.55 mc, were implanted in the tumor giving an estimated tumor dose of 5,500 rads. Because certain authorities at that time expressed concern over the possible radiation hazard, no further implants were carried out for several years. Although the patient had initially 213 mc of chromium in a permanent implant, only 10 per cent of the isotope decays with a sufficiently energetic gamma ray to be detected. The chromium is extremely inert and no radioactivity was found in either the stool, urine, or expired air.

This patient has remained asymptomatic. Pelvic examination shows an indurated area in the region of the previously described mass, but there has been no progression in this area, nor have metastases been observed in over 7½ years.

Two years ago we received permission to continue clinical investigation of these sources provided the patients with such implants were correctly identified by an arm band and a wallet card. Since that time 24 patients have received 30 implants. Most of these patients have received maximum therapy from external beam radiation and from radium. Some of the patients have had radical surgery and chemotherapy, including perfusion. Tables I, II and III outline the experience in these patients. We have seen necrosis and hemorrhage in 3 instances. This has occurred in patients who have been heavily irradiated previous to implantation of the chromium. Four patients have had 2 implants and 1 patient has had 3 implants. Where we have made repeated implants we have used seeds of 2.5 to 3 mc in activity. We have seen excellent response in 9 patients. In these patients the area irradiated has shown good local control. A number of patients have had deep seated tumors which could be exposed sufficiently to allow implantation at the time of surgery. Figure 4 is a roentgenogram of an implant done 1½ years prior to this study. At surgery, metastatic lymph nodes from carcinoma of the cervix were implanted. The patient's pain was relieved and swelling of the leg decreased. Chromium 51, with its relatively long

TABLE III

QUESTIONABLE OR UNFAVORABLE RESULTS AND INSUFFICIENT TIME FOR EVALUATION

Patient	Diagnosis	Previous Treatment	No. of Chromium Seeds and Activity	Calculated Dose	Comments
R.T.	Transitional cell carcinoma of bladder	Roentgen therapy and surgery	[illegible]	[illegible] rads	Died of cystitis and sepsis [illegible]; insufficient time to evaluate
V.M.	Squamous cell carcinoma of cheek	Surgery and roentgen therapy	[illegible]	4,[illegible] rads	Died of hemorrhage [illegible] months later [illegible]
A.S.	Carcinoma of cervix with vaginal recurrence	Radium and roentgen therapy	[illegible]	[illegible] rads	Necrosis and tumor present at autopsy [illegible] later
E.M.	Mucoepidermoid carcinoma of nasopharynx	Surgery and roentgen therapy	[illegible]	[illegible] rads	Normal reaction at [illegible] weeks. Insufficient follow-up
A.K.	Squamous cell carcinoma of posterior tongue	Roentgen therapy	[illegible]	[illegible] rads	Transient response of [illegible] months duration [illegible] tongue lesions
M.R.	Carcinoma of cervix with involvement of bladder	Roentgen therapy [illegible]	[illegible]	[illegible] rads	Necrosis of anterior vaginal wall. Marked relief of pain and decrease in infiltration in parametrium
O.L.	Squamous cell carcinoma of buccal mucosa	Roentgen therapy	[illegible]	4,[illegible] rads	Only temporary decrease in [illegible] metastases

half-life, allows us to keep a supply of radioactive chromium seeds in stock in a sterilized lead pot. Two implantation guns are available and sterilized [illegible]. Those sources that decay one half-life become half strength seeds for use in implantations where a tissue dose of between 2,000 and 3,000 rads is desired. Eight of the implants have been done under local anesthesia in the out-patient clinic.

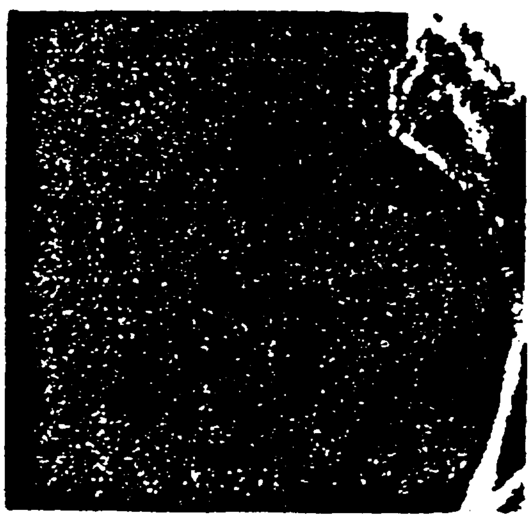

FIG. 4. A roentgenogram of an implant of a patient with recurrent carcinoma of the cervix with metastatic tumor in iliac lymph nodes.

DISCUSSION

We have found chromium 51 seeds to be very flexible and useful sources for interstitial implantation. The relatively long half-life, the absence of beta irradiation, and the ease of handling have been important features. It has been possible to keep a stock of radioactive sources constantly available, sterilized and ready for operative implantation in deep seated tumors. There has been a relatively low incidence of tissue necrosis, and in previously irradiated areas, the additional irradiation from this permanent implant has been generally well tolerated. It may be that the relatively low dose rate from these permanent implants allows the normal tissue to proliferate and repopulate the irradiated area.

We are currently using a computer program to investigate the possibilities of improving our dosimetry in these implants. The late effects of these long lived permanent interstitial implants are also being investigated.

SUMMARY

1. The clinical use of a permanent chromium 51 implantation technique is described.

2. Twenty-five patients have had 3[illegible]

implants, the longest being in place for 7.5 years.

3. The fabrication, preparation, physical properties, and clinical use of these interstitial sources are described.

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