Ions and Computers Fight Cancer

The newest form of radiation therapy is posting some successes

By DIETRICK E. THOMSEN

Radiation has been used in medical therapeutics for several decades. Until recently it has virtually always been photons, the particles of light, that were employed. Various parts of the light spectrum have been used — even visible light, in some therapies (SN: 6/22/74, p. 404) — but most familiar is the use of high energy photons, X-rays and gamma rays to kill tumors.

Some kinds of tumors resist gamma rays. Tumors that could be treated with gamma rays are sometimes located in such a way that the treatment would cause unacceptable damage to nearby healthy tissues. Recent developments in subatomic physics are now giving medical therapists other options, other kinds of radiation, for some of these cases. Several laboratories are using pions to irradiate tumors (SN: 12/9/78, p. 410). Now some early success is reported in the treatment of certain tumors with protons and helium ions.

Most of the tumors that have been treated this new way are malignant eye tumors known as choroidal melanomas, a rare disease afflicting about six persons per million per year in the United States. The tumors start in the choroid layer at the back of the eye and usually protrude into the eyeball, says Devron Char, director of the Ocular Oncology Unit at the University of California at San Francisco and one of the leaders of the group that is treating the affliction with helium ions. Until now, a common treatment for the disease has been surgical removal of the afflicted eye; another method is to place a plaque containing radioactive cobalt behind the eye to irradiate the tumor with gamma rays. But the gamma rays, Char says, are not uniform and are unfocusable. In the course of irradiating the tumor, the optic nerve and the fovea can also be irradiated and vision destroyed. In addition, says Char, 50 percent of eyes treated with plaques are lost to radiation complications or tumor regrowth.

What the beams of ions, either protons (hydrogen ions) or helium ions, can do is destroy the tumor without destroying the eye, preserving partial vision in a majority of cases. Of the 130 patients treated so far, Char says, 90 percent have been treated successfully — with success defined as retention of the eye for up to six years, tumor control and no development of new tumors in other parts of the body spawned by the old one. Such metastases occur within five years of treatment in about 50 percent of patients treated in other ways. So far this group has not seen the development of widespread disease after treatment in patients who had not had widespread disease before. "I'm sure we will, eventually," says Char.

Indeed, whether that and other complications will appear with longer follow-up is one of the major concerns of Char and William M. Saunders and Joseh R. Castro, physicians with the Lawrence Berkeley Laboratory (LBL) in Berkeley, Calif., who are the other leaders of the group. So far the longest follow-up they have for any patient is six years, and the average is 18 months. For a proper evaluation of the relative usefulness of this technique against the others, much longer follow-up is necessary.

Treatment takes place at LBL, where the 184-inch cyclotron supplies the helium ions. Use of ions against choroidal melanomas was started by a group led by Herman Suit of Massachusetts General Hospital in Boston. The Massachusetts group uses protons from the synchrocyclotron at Harvard University in Cambridge. The California group, having heavier ions available from the Berkeley cyclotron, decided to try them. Beginning with helium, they have had such good results, Char

Doctoring with a computer

The method of treating the choroidal melanomas combines advanced medicine, physics and computer science. It begins with an age-old medical procedure, visual assessment — the tumors can be seen by looking into the eyeball — and proceeds rapidly to a computer-designed and -controlled treatment plan tailored to each individual patient.

After visual evaluation, wide angle photographs are taken. Ultrasound scans add further depth. Detailed scale drawings are made. Char then does a surgical procedure in which he sews tantalum rings two millimeters in diameter to the outside of the eye to locate the tumor. This is done because the tumor does not show up on X-ray pictures, and X-rays (of the diagnostic, not the treatment, sort) will be used to monitor the treatment. The patient can wear the rings indefinitely, Char says.

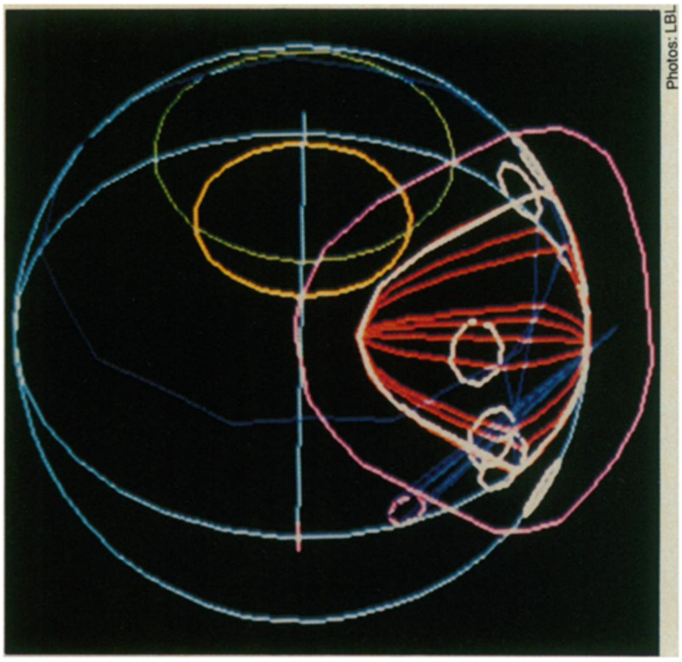
Now the computer goes to work using a program written by a member of the Massachusetts group. The LBL computer presents, in several colors, drawings of the given patient's eye with the tumor, optic disk, fovea, lens, cornea and implanted tantalum rings displayed. It can give external views of the eye from various angles. And it can give the beam's eye view with the tumor wrapped around the field of sight. It calculates dosages for various angles of entry and draws isodose lines on the eye to show which structures will get which dose. With this information the physician and physicist can plan the entry angle of the dose and design a metal mask to give it the proper cross-section. When they started, Saunders says, they thought they might come up with four or five mask shapes that they could reuse over and over, but they're up to 130 now, and each is individual.

The beam is designed to give a slight overlap to ensure coverage of the tumor. Still, says Char, if the tumor lies at least 4 millimeters from the optic nerve, they can destroy the tumor and not destroy the optic nerve along with it. If the optimum entry angle requires going through the lens, he says, cataract is likely to develop. "A cataract, if you have to get one, is not a very major problem," Char says. "In fact we've had very few." Some patients develop glaucoma, but whether that is an effect of the radiation or of having a large tumor for a long time, Char doesn't know.

In treatment the patient is held rigid in a contoured chair that can be swiveled to fit the beam geometry and an individually cast polystyrene facemask. The patient looks at a red guiding light to hold the eye steady. An X-ray is taken to check alignments. Infrared light illuminates the inside of the eye throughout the treatment and is imaged on an infrared-sensitive TV screen. A side-looking laser monitors the position of the ion beam. It takes five treatments equivalent to about 6,000 rads of conventional radiation to kill the tumor.

—D. E. Thomsen

Wide angle photo of the back of a cancerous eye taken through the pupil and eyeball. The tumor is large mass on the right.



Photos: LBL

Computer drawing of cancerous eye as ion beam would see it. Green circle is the iris; yellow is the lens. Optic nerve is the blue bundle, cancer is orange. White circles are tantalum rings sewn in for reference. Pink outlines entire target area.

says, that they don't intend to go to any heavier ions for the choroidal melanomas. A third group is now getting started in Switzerland.

Heavier ions, supplied by the cyclotron or by the Bevalac, LBL's other ion accelerator, are being used in a program to determine whether they will be useful against the kind of tumors that resist treatment with X-rays or gamma rays. Saunders points out that the tumors with which they have so far had some success with helium ions — both the choroidal melanomas and certain spinal tumors — are the sort that also respond to gamma rays or X-rays. It had been hoped, and it is still hoped, that ion beams would provide a way to kill the X-ray-resistant tumors. Heavier ions may provide it.

The advantage that the helium beams provide over X-rays in treatment of the eye and spine tumors comes largely from the nature of the ion beam and the location and geometry of the tumors. Ion beams deliver most of their energy at the end of their path; X-ray beams deliver energy to all the flesh they traverse, starting as soon as they enter the body. Ion beams are electrically charged and so are easier to guide and focus than X-rays.

For deep-lying tumors or for tumors lying close to vital organs, use of X-rays may damage vital, healthy tissue. This is true in the eye, where the therapists want to preserve as much sight as they can. It is also true in the spine, where the tumors tend to wrap around the spinal cord.

The problem becomes one of geometry: locating and delineating the tumor, shaping and angling the treatment beam and making sure the patient doesn't destroy the alignments by moving. The eye is a good place to start this kind of program, says Saunders. "It is an accessible and visible organ."

Spinal cord tumors can't be seen from outside the body, and are located and delineated by means of CAT (Computer Assisted Tomography) scans. Patients lie down in a conventional CAT scanner. A special CAT scanner, in which the patient sits up, had to be devised. The CAT scan has to be done in the same position as the treatment so that the locations of internal organs will be the same. Spine tumors may be located anywhere from the base of the skull to the chest. They tend to lie between the vertebrae and wrap around the spinal cord. "The patients can't be treated any other way," Saunders says. The spine tumor program is just beginning, and so far, Saunders says, they don't have the numbers or follow-up time to say whether the treatment is successful.

The inventor of the cyclotron, the late Ernest O. Lawrence, had a lifelong interest in the possibilities of treating cancer with subatomic particles. He would certainly be pleased to know that cancers are now actually being treated in the laboratory named for him with the kind of accelerator he invented. □