Proton Therapy

What is proton therapy and how is it used?

Protons are atoms that carry a positive charge. Just as x-rays (also known as photons) are used to treat both benign and malignant tumors, a beam of protons can be used to irradiate tumors in the same way. There is no significant difference in the biological effects of protons versus photons (x-rays). Physically, although they do deliver a dose of radiation to the normal tissues as they enter the body, protons release most of their energy when they hit the tumor and deliver no exit dose beyond the tumor boundary, unlike photons. Therefore, especially for smaller tumor sizes, the dose of radiationmay conform to the tumor better and there may be less damage to healthy tissue. As a result, the treating physician (a radiation oncologist) can potentially give an even greater dose to the tumor while minimizing unwanted side effects. This is especially important when treating children, because it reduces radiation to growing and developing tissues.

Proton therapy is being used to treat tumors in these areas of the body with encouraging early results:

- Lung - see the Lung Cancer page (www.RadiologyInfo.org/en/info.cfm?pg=lungcancer)
- Prostate - see the Prostate Cancer page (www.RadiologyInfo.org/en/info.cfm?pg=pros_cancer)
- Brain - see the Brain Tumors page (www.RadiologyInfo.org/en/info.cfm?pg=thera-brain)
- Spinal or vertebral body tumors
- Skull base sarcomas
- Pediatric brain tumors
- Head and neck - see the Head and Neck Cancer page (www.RadiologyInfo.org/en/info.cfm?pg=hdneck)
- Eye melanomas

Protocols are being developed to explore the use of protons in other parts of the body.

Who will be involved in this procedure?

Proton beam therapy requires a treatment team, including a radiation oncologist, radiation physicist, dosimetrist, immobilization specialist, radiation therapist, and nurse. The radiation oncologist is a specially trained physician who evaluates the patient and determines the appropriate therapy, specific area for treatment, and radiation dose. Working together, the radiation oncologist, radiation physicist, dosimetrist and radiation therapist establish the best way to

deliver the prescribed dose. The radiation physicist and the dosimetrist then make detailed treatment calculations. Radiation therapists are specially trained technologists who perform the daily radiation treatments. Imaging studies are very important in delivering this treatment and a diagnostic radiologist is often involved with planning, too. Radiation therapy nurses are team members who tend to your day-to-day concerns and help to manage the side effects of the treatment.

What equipment is used?

Proton beam therapy uses a special machine called a cyclotron or a synchrotron to generate and accelerate protons. The protons leave the machine and are steered by magnets toward the tumor. Other pieces of equipment are used to modify the range of the protons, shape of the beam, and to compensate for organ location.

Who operates the equipment?

With backgrounds in mechanical, electrical, software, hardware and controls, specialized operators maintain, upgrade and repair the cyclotron or synchrotron and radiation delivery system. They are also present in the facility's main control room during treatments in order to monitor the performance of the radiation delivery system.

Is there any special preparation needed for the procedure?

Before a patient begins proton therapy, there are a few preparation steps. First, the patient will be fitted for an immobilization device to put his or her body in the exact same position for each therapy treatment. The device used will depend upon the location of the tumor. Patients with a tumor below the neck may have a full-body mold made of foam liners surrounded by rigid plastic shells. Patients with a tumor in the eye, brain or head will be fitted with a custom-made mask.

Once the immobilization device is constructed, patients will often undergo computed tomography (CT) or magnetic resonance imaging (MRI) scanning to create a 3-D reconstruction of the tumor to define its boundaries with the surrounding normal structures. The patient has the CT scan performed in the treatment position, using the device, so that it can be taken into account for treatment planning. Sometimes a CT or MRI scan is done prior to mask-fitting. In the case of eye melanoma patients with tantalum rings sutured, simple x-rays may be taken to image the rings' placement.

The radiation oncologist uses a computer to trace the tumor and the surrounding normal tissues. Physicists and dosimetrists create a treatment plan on the computer that outlines a single or multiple proton beams entering at various angles. They use this to calculate the radiation dose that the tumor will receive. After the physician reviews this plan, it is transferred to automated machines that make the special devices, apertures and tissue-compensating filters that will be used during therapy. All of these devices are calibrated by the physics support staff before the patient's first treatment to ensure that the planning and fabrication have been done correctly.

How is the procedure performed?

The procedure is performed on an outpatient basis. For most tumor sites, the average course of treatment is usually five to seven weeks, but rarely, certain tumors treatment may last only a few days. The length of each treatment will vary depending upon the tumor type and stage. The delivery of the proton beam to the patient lasts only about a minute, although the total time spent in the treatment room will be longer (about 15-20 minutes) for positioning and adjustments to the equipment settings.

For daily treatments, the patient enters the treatment room and is fitted with his or her personal immobilization device. The patient is positioned with the aid of laser sights to within a half-centimeter accuracy. The radiation therapist then takes several low-energy diagnostic radiographs (x-rays) or digital images to insure proper alignment. This process is repeated before each treatment. In some cases a fan beam CT system will be used to image the target before each treatment.

Special apertures and filters that are made for each patient are loaded into the beam line. A computer may be used to scan and verify the individual bar codes on these devices. Once positioning and treatment parameters are verified, the radiation oncologist and technologists step out into a control room located next to the treatment room and begin the treatment. After the prescribed radiation dose has been delivered, the computer shuts off the proton beam and the technologists re-enter the room to assist the patient in removing the mask or immobilization device.

What will I feel during and after the procedure?

You should not feel any pain or discomfort from the proton beam. Afterward, there may be some side effects, and they will be managed by your radiation oncologist in the same way they would be for any course of radiation. Other factors that may influence how well you feel after treatment are how big a dose you are given and whether you are also getting chemotherapy at the same time. Common side effects include temporary hair loss and skin reactions in the direct path of the radiation and fatigue, especially when a large area is being treated.

Side effects of radiation treatment include problems that occur as a result of the treatment itself as well as from radiation damage to healthy cells in the treatment area.

The number and severity of side effects you experience will depend on the type of radiation and dosage you receive and the part of your body being treated. You should talk to your doctor and nurse about any side effects you experience so they can help you manage them.

Radiation therapy can cause early and late side effects. Early side effects occur during or immediately after treatment and are typically gone within a few weeks. Common early side effects of radiation therapy include tiredness or fatigue and skin problems. Skin in the treatment area may become more sensitive, red, irritated, or swollen. Other skin changes include dryness, itching, peeling and blistering.

Depending on the area being treated, other early side effects may include:

- hair loss in the treatment area
- mouth problems and difficulty swallowing
- eating and digestion problems
- diarrhea

- nausea and vomiting
- headaches
- soreness and swelling in the treatment area
- urinary and bladder changes

Late side effects, which are rare, occur months or years following treatment and are often permanent. They include:

- brain changes
- spinal cord changes
- lung changes
- kidney changes
- colon and rectal changes
- infertility
- joint changes
- lymphedema
- mouth changes
- secondary cancer

There is a slight risk of developing cancer from radiation therapy. Following radiation treatment for cancer, you should be checked on a regular basis by your radiation oncologist for recurring and new cancers.

Using techniques such as proton therapy, imaging specialists are maximizing the cancer-destroying capabilities of radiation treatment while minimizing its effect on healthy tissues and organs and the side effects of the treatment itself.