Proton Therapy [1]

This section has been reviewed and approved by the Cancer.Net Editorial Board [2], 07/2015

Proton therapy, also called proton beam therapy, is a type of radiation treatment that uses protons rather than x-rays to treat cancer. A proton is a positively charged particle. At high energy, protons can destroy cancer cells. Doctors may use proton therapy alone, or they may combine it with standard radiation therapy, surgery, chemotherapy, and/or immunotherapy.

Like standard x-ray radiation therapy, proton therapy is a type of external-beam radiation therapy. It painlessly delivers radiation through the skin from a machine outside the body.

How proton therapy works

A machine called a synchrotron or cyclotron speeds up the protons. The speed of the protons reflects their high energy. The protons travel to a specific depth in the body based on their energy.

After the protons reach the desired place in the body, they deposit the specified radiation dose in the tumor. With proton therapy, there is no radiation dose beyond the tumor. In contrast, x-rays continue to deposit radiation doses as they exit the patient's body. This means that radiation is also damaging nearby healthy tissues, potentially causing side effects.

What to expect

Patients often receive proton therapy in an outpatient setting. This means treatment does not require hospital admission. The number of treatment sessions depends on the type and stage of the cancer. Sometimes, doctors deliver proton therapy in one to five proton beam treatments, generally using larger daily radiation doses. This is typically referred to as stereotactic body

radiotherapy. If a person receives a single, large radiation dose, it is sometimes called radiosurgery.

Treatment planning

Proton treatment requires planning. Before treatment, the patient undergoes a specialized computed tomography [3] (CT) or magnetic resonance imaging [4] (MRI) scan. During this scan, the patient is put in the exact same position that will be used for treatment. However, this requires that the doctor limits a person's movement while having the scan.

To help keep the patient in one place, he or she may be fitted with a device that restricts movement. The type of device depends on where the tumor is located. For example, a patient may need to wear a custom-made mask for a tumor in the eye, brain, or head.

The patient will also need to wear this device later for the radiation planning scan. The table on which the patient lies for the radiation planning scan allows the scan to be referenced to the marks on the person's body or the immobilization device. This helps ensure the patient's position is accurate during each proton treatment.

The immobilization devices are designed to fit snugly so that there is no motion during the radiation treatment. However, the radiation oncology team wants each person to be as comfortable as possible during treatment. It is important for patients to communicate with the team to find a comfortable and reproducible position for treatment. Some patients, particularly with tumors around the head and neck region, feel somewhat anxious when they need to lie still in such an immobilizing device. It is important to let the members of the radiation oncology team know if this causes you anxiety. Your doctor can prescribe medication to help you relax for the treatment planning scan and the treatments.

Using the radiation treatment scan, a member of the radiation oncology team draws the tumor area(s) to be treated. He or she also draws the normal tissues to be avoided. This process is similar to the process for planning radiation therapy with x-rays.

Receiving treatment

Treatment is delivered in a special treatment room. For each treatment, a member of the team will bring the patient into this room. He or she will place the person into the immobilization device on the treatment table. For some areas around the head and neck like the eye, the patient is positioned in a specialized chair, instead of being on a table.

The treatment team will take great care to make sure the patient is in the correct position before beginning treatment. This involves the use of alignment lasers centered on marks placed on your body or the immobilization device at the time of the treatment planning scan. A member of the team takes X-rays or CT scan pictures before every radiation treatment to be sure that the patient is in the exact same position as the treatment planning. This is so that the protons hit the tumor and not the tissues near the tumor.

Some proton treatment rooms are equipped with what is called a gantry. It rotates around the patient. This ensures that the radiation is delivered to the tumor from the best angles to treat the cancer. During the patient positioning process, you may notice that the gantry will also be rotated around you so that the radiation delivery “snout”, from which the protons emerge, is in the desired position.

Once you have been accurately positioned, the members of the radiation oncology treatment will leave the treatment room and go to the treatment delivery controls outside the room. They will be able to see you and hear you with video equipment mounted in the treatment room. They will use the treatment program controls on the machine console outside the treatment room to deliver your proton treatment.

The protons leave the cyclotron or the synchrotron machine. Magnets then direct them to the tumor, sometimes using the gantry as described above. During the treatment, the patient must stay still to avoid moving the tumor out of the focused proton beam.

Time needed for each treatment

In general, patients can expect a proton radiation treatment to last about 15 to 30 minutes from the time they enter the treatment room. These times vary based on a number of factors including the body site(s) being treated, number of treatment segments, and the ease with which the radiation oncology team member can see the tumor site with x-rays or CT scans during the positioning process.

Patients should ask their radiation oncology treatment team approximately how long each radiation treatment will take. Sometimes the doctor will need to give several segments from different gantry angles. Clarify with your radiation oncology treatment team if this will happen for your treatment. Ask where they will come back into the room between segments to reposition the gantry or whether the gantry will be rotated around you remotely.

It is also important to realize that total time in the treatment room may vary from day to day. This is because the doctor will target different areas that require different radiation “fields” using different kinds of proton beam segments. For example, one radiation treatment may be designed to deliver a portion of the total radiation dose to lymph nodes and healthy tissues around the tumor that may contain microscopic amounts of tumor. Another may be designed to deliver a radiation dose to the dominant tumor.

Even when the same target field is being treated on different days, other factors may affect the treatment time. One is waiting for the proton beam to be re-directed into your room after another patient’s treatment is finished. This is because nearly all proton treatment facilities have only a single proton cyclotron or synchrotron.

In facilities that have more than one treatment room, the protons are magnetically steered to one room to the next. On some days, two different rooms may be ready at nearly the same time to deliver the proton treatment to the patient in each room. This means that one patient may

have to wait a couple of minutes until the first patient's proton treatment has been delivered and the beam can be directed to the next patient's room.

Side effects

The treatment itself is painless. Afterwards, you may experience fatigue and skin problems, including redness, irritation, swelling, redness, dryness, or blistering and peeling. You may experience other side effects, especially if you are also receiving chemotherapy. The side effects of proton therapy depends on the part of the body being treated, the size of the tumor, the types of healthy tissue next to the tumor, and whether you will receive chemotherapy at the same time. Your radiation oncology doctors and nurses will discuss which side effects are most likely for you.

Cancers treated with proton therapy

Proton therapy is useful for treating tumors that have not spread and for tumors near important parts of the body, such as near the eye, the brain, and the spinal cord. It is also used for treating children because it lessens the chance of harming healthy, developing tissue. Children may receive proton therapy for cancers of the brain and spinal cord and the eye, such as retinoblastoma and orbital rhabdomyosarcoma.

Proton therapy also may be used to treat these cancers:

- Central nervous system cancers, including chordoma, chondrosarcoma, and malignant meningioma
- Eye cancer, including uveal melanoma or choroidal melanoma
- Head and neck cancers, including nasal cavity and paranasal sinus cancer and some nasopharyngeal cancers
- Lung cancer
- Liver cancer
- Prostate cancer
- Spinal and pelvic sarcomas, which are cancers that occur in the soft-tissue and bone
- Noncancerous brain tumors

Risks and benefits

Compared with standard radiation treatment, proton therapy has several benefits:

- Up to 60% less radiation generally can be delivered to the normal tissues around the tumor, which lowers the risk of radiation damage to healthy tissues.
- It may allow for a higher radiation dose to the tumor, which increases the chances that all of the tumor cells in the tumor targeted by the proton radiation will be destroyed.
- It may result in fewer and less severe side effects such as low blood counts, fatigue, and

nausea during and after treatment.

However, there are some drawbacks:

- Because proton therapy requires highly specialized, expensive equipment, it is available at just a few medical centers in the United States. Find a list of medical centers that currently offer proton therapy [5].
- It may cost more than conventional radiation therapy. Insurance provider rules vary about which diagnoses are covered and how much patients need to pay. Talk with your insurance provider to learn more.
- Not all cancers can be treated with proton therapy.

Ongoing research

Several ongoing randomized controlled clinical studies are comparing x-ray treatments to proton treatments. These are being conducted for several reasons:

- In organs where the tumor and the adjacent normal tissues are moving, such as the lung, there may be a higher risk of not giving a large enough dose when compared with x-rays.
- In other areas of the body, sophisticated x-ray treatments produce excellent results with a low risk of significant radiation-associated side effects. For these tumors, clinical studies are needed to find out whether proton is better than x-rays, given the higher cost of proton therapy.

More Information

What is Radiation Therapy? [6]

What to Expect When Having Radiation Therapy [7]

Side Effects [8]

Additional Resource

RadiologyInfo: Proton Therapy [9]

Links
[1] http://www.cancer.net/navigating-cancer-care/how-cancer-treated/radiation-therapy/proton-therapy
[2] http://www.cancer.net/about-us
[3] http://www.cancer.net/node/24486
[4] http://www.cancer.net/node/24578
[5] http://www.proton-therapy.org/map.htm
[6] http://www.cancer.net/node/24728

[7] http://www.cancer.net/node/24661
[8] http://www.cancer.net/node/25238
[9] http://www.radiologyinfo.org/en/info.cfm?pg=protonthera&bhcp=1