AMERICAN BRAIN TUMOR ASSOCIATION

Proton Therapy



American Brain Tumor Association®

Providing and pursuing answers®

ABOUT THE AMERICAN BRAIN TUMOR ASSOCIATION

Founded in 1973, the American Brain Tumor Association (ABTA) was the first national nonprofit organization dedicated solely to brain tumor research. For over 40 years, the Chicago-based ABTA has been providing comprehensive resources that support the complex needs of brain tumor patients and caregivers, as well as the critical funding of research in the pursuit of breakthroughs in brain tumor diagnosis, treatment and care.

To learn more about the ABTA, visit www.abta.org.

We gratefully acknowledge Anita Mahajan, Director of International Development, MD Anderson Proton Therapy Center, director, Pediatric Radiation Oncology, co-section head of Pediatric and CNS Radiation Oncology, The University of Texas MD Anderson Cancer Center; Kevin S. Oh, MD, Department of Radiation Oncology, Massachusetts General Hospital; and Sridhar Nimmagadda, PhD, assistant professor of Radiology, Medicine and Oncology, Johns Hopkins University, for their review of this edition of this publication.

Proton Therapy

INTRODUCTION

Brain tumors are highly variable in their treatment and prognosis. Many are benign and treated conservatively, while others are malignant and require aggressive combinations of surgery, radiation and chemotherapy. The goal of all radiation therapy is to destroy tumor cells and prevent regrowth, while protecting the healthy tissue that surrounds the tumor. This is especially important for young children, as their developing brains and bodies are extremely sensitive to the potential long-term effects of radiation.

Radiation therapy kills brain tumor cells, and/or slows their growth by sending energy particles to the tumor and a margin – or border – of normal tissue surrounding the tumor. The extended treatment area allows for the possibility that the tumor may have spread into surrounding tissue. Often, this margin includes some healthy brain tissue, and possibly, surrounding structures near the tumor, which, if damaged, may result in long-term side effects.

WHAT IS PROTON THERAPY?

Proton therapy is an established, advanced form of radiation treatment that can deliver necessary doses of radiation while minimizing radiation doses to adjacent

brain tissue. It takes just minutes to deliver a high level of radiation in a number of treatment sessions.

Proton therapy uses accelerated subatomic particles called protons (energized particles that have a positive charge) to send a high level of energy directly to the tumor site through a magnetically-guided beam. In proton therapy, energy of the protons – along with the depth of penetration – can be conformed to match the unique size and shape of each tumor. This helps to minimize the destruction of surrounding healthy tissue and organs and theoretically decreases acute and long-term side effects, such as neurocognitive deficits (e.g., short-term memory problems) and hypopituitarism (i.e., hormonal imbalances).

Proton therapy is typically recommended for the treatment of tumors that are irregularly shaped, located in hard to reach areas and/or located near critical organs and brain tissue. The procedure is typically not recommended for tumors that have spread, or for tumors that have metastasized to other areas of the body. Proton therapy has the potential to deliver high doses of radiation, directly within the boundaries of a tumor, within minutes. It may be part of a

The gantry rotates and directs the protons to the patient's tumor.
Photo courtesy of MD Anderson Proton Therapy Center

comprehensive treatment plan that also includes surgery and/or chemotherapy.

Brain tumors that may be suitable for proton therapy include:

- Some brain tumors that have previously received radiation
- Benign tumors:
  - Vestibular schwannomas/acoustic neuromas
  - Meningiomas
  - Pituitary adenomas
  - Arteriovenous malformations
- Certain low- and high-grade gliomas
- Chordomas
- Chondrosarcomas
- Pediatric brain tumors, including:
  - Juvenile pilocytic astrocytomas (JPA)
  - Ependymomas
  - Medulloblastomas
  - Germ cell tumors
- Pineal tumors

THE HISTORY OF PROTON THERAPY

The acceleration of protons has evolved from a process primarily used to test the limits and possibilities of nuclear physics to a more readily available and effective medical therapy.

Proton therapy requires the acceleration of particles – specifically, hydrogen atoms with electrons removed – to create high levels of precisely directed energy. The protons are energized in a particle accelerator called a cyclotron. The first cyclotron was built in the 1930s at the Berkeley Radiation Laboratory at the University of California, Berkeley. It was not until 1946 that Robert R. Wilson, a professor of physics at Harvard University, first proposed using proton acceleration for the treatment

of cancer. In 1954, the first cancer patient received proton therapy at the Berkeley Radiation Laboratory. Cyclotrons and proton therapy programs followed at Harvard University (1961), the University of California, Davis (1964) and the Los Alamos National Laboratory (1974).

For decades, proton therapy remained a cancer treatment offered at a limited number of physics laboratories. In the meantime, other advancements in the diagnosis and treatment of cancer continued to evolve. These advancements ultimately helped make proton therapy a more effective and precise treatment. These included the creation and improvement of:

- computed tomography (CT) and magnetic resonance imaging (MRI) to identify the location and borders of a tumor and normal tissues
- 3D conformal technology – computer software that creates a three-dimensional virtual model of a tumor or tumor cavity, allowing for the precise delivery of treatment
- patient immobilization devices to ensure the patient's stability during treatment

While proton therapy has been used to treat tumors for nearly 60 years, it has more recently become approved in the United States. In 1988, proton therapy received U.S. Food and Drug Administration (FDA) approval for the treatment of certain cancers, including brain tumors. In 1991, Loma Linda Medical Center in California opened the first hospital-based proton therapy treatment center with a modified cyclotron (more suitable for a hospital or medical center), called a synchrotron. In 2006, there were five proton therapy treatment centers in the U.S. By 2012, that number had risen to 10 with another seven in various stages of construction and development.

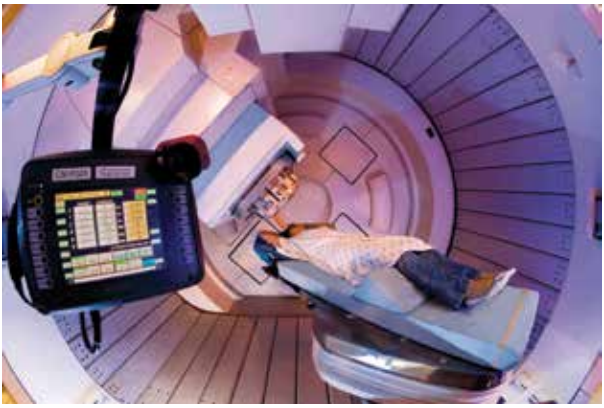
A patient is fitted with a face mask.
Photo courtesy of MD Anderson Proton Therapy Center

HOW PROTON THERAPY WORKS

Through proton therapy, highly energized protons are delivered from a synchrotron or cyclotron through a precisely controlled conformal beam to a patient's tumor. Energy of the delivered protons is adjusted based on the tumor location, size and shape in the brain.

Each patient treatment room includes a robotic bed which serves as a stable platform that positions the patient during the procedure. Newer room designs will include CT equipment to help determine the shape of the tumor and to guide the direction of the proton beam.

Patients typically attend a pre-treatment imaging session known as a simulation, during which they are fitted with a positioning device that will help to precisely direct the proton beam during the actual procedure. Pre-treatment imaging may occur a week or two in advance of the first proton therapy session to allow for planning and calculation of the treatment.



The gantry with a patient during the procedure.
Photo courtesy of MD Anderson Proton Therapy Center

During the proton therapy session, the medical attendant leaves the room. The patient's treatment table is then directed into the gantry, a donut-shaped, rotating steel device which is approximately 35 feet in diameter. The gantry rotates around the table, directing the accelerated protons to the patient's tumor through the beam delivery system, called an aperture. The duration of each treatment session is about 30–90 minutes, and the patient neither hears nor feels the procedure.

PENCIL BEAM PROTON THERAPY

Another typer of proton therapy, called pencil beam proton therapy, delivers a single, narrower proton beam that is magnetically swept across the tumor, without the need for a beam-shaping device. This technology provides an even more precise three-dimensional beam that conforms to the shape and depth of the tumor. Pencil beam proton therapy further diminishes the risk of impacting surrounding healthy brain tissue and adjacent, critical organs, lowering the risk for side effects. Pencil beam proton therapy often is recommended for tumors with complex shapes located in close proximity to critical organs.

PROTON THERAPY FOR CHILDREN

Conventional radiation therapy, while helpful in treating the tumor, often comes with side effects, some of which can have a negative impact on a young child's growth and development, as well as increase the risk of a radiation-related tumor later in life. Depending on the tumor type, conventional radiation therapy for pediatric brain tumors may include regions near (but not involving) the neuro-endocrine structures as well as the entire spinal canal.

Unlike conventional radiation, proton therapy is able to deliver the necessary radiation dose to the targeted tumor area while minimizing the impact on the neuro-endocrine structures, normal brain and tissue in front of the spinal column (like heart, lungs and bowel). This benefit is particularly important for young children who are still developing. Less damage to healthy tissue means potentially reducing the development and intelligence changes that can occur with conventional radiation. Additionally, studies show that proton therapy can also result in fewer late effects, including secondary tumors from treatment, a major concern among physicians and families when a child – especially a very young child – is undergoing radiation treatment.

Children often tolerate proton therapy well, as it is non-invasive, painless and typically results in fewer side effects. Younger children may need to be sedated if they cannot remain still during the procedure. The treatments are typically administered five days per week for five to six weeks. The child usually feels well enough to continue normal activities following proton therapy treatments.

BENEFITS OF PROTON THERAPY

The greatest benefit proton therapy offers is the reduced negative impact on the tissue and structures that are near the tumor. Proton therapy results in a significantly smaller amount of energy being deposited as the radiation travels to the tumor site. The energy can be adjusted to

stop the protons at the tumor site. This is different from conventional radiation, which irradiates healthy cells as it travels beyond the tumor site. Sparing healthy tissues and organs helps reduce the impact of side effects common in conventional radiation therapy and allows for treatment in difficult locations in the body.

SIDE EFFECTS

As with all radiation therapy, there is the potential for side effects. Most people, however, report far fewer side effects as a result of proton therapy. If they do occur, side effects are generally minor and vary depending on the tumor location, general health, other medical conditions, age and medical history. Some people experience tiredness, skin irritation, hair loss in the treated area, nausea and headache.

THE ABTA IS HERE FOR YOU

You don't have to go through this journey alone. The American Brain Tumor Association is here to help.

Visit us at www.abta.org to find additional brochures, read about research and treatment updates, connect with a support community, join a local event and more.

We can help you better understand brain tumors, treatment options, and support resources. Our team of health care professionals are available via email at abtacares@abta.org or via our toll-free CareLine at 800-886-ABTA (2282).

MORE INFORMATION ON PROTON THERAPY

The U.S. National Library of Medicine/National Institutes of Health
(type in "proton therapy" in search bar):
www.nlm.nih.gov

AMERICAN BRAIN TUMOR ASSOCIATION PUBLICATIONS AND SERVICES

CARE & SUPPORT

CareLine: 800-886-ABTA (2282)
Email: abtacares@abta.org

PUBLICATIONS

About Brain Tumors: A Primer for Patients and Caregivers

Tumor Types:

Ependymoma
Glioblastoma and Malignant Astrocytoma
Medulloblastoma
Meningioma
Metastatic Brain Tumors
Oligodendroglioma and Oligoastrocytoma
Pituitary Tumors

Treatments:

Chemotherapy
Clinical Trials
Conventional Radiation Therapy
Proton Therapy
Stereotactic Radiosurgery*
Steroids
Surgery

*All publications are available for download in Spanish. (exception is marked *)*

CLINICAL TRIALS

TrialConnect®: www.abtatrialconnect.org or 877-769-4833

More brain tumor resources and information are available at www.abta.org.

AMERICAN BRAIN TUMOR ASSOCIATION

8550 W. Bryn Mawr Avenue, Suite 550
Chicago IL 60631

For more information contact:

CareLine: 800-886-ABTA (2282)
Email: abtacares@abta.org
Website: www.abta.org

To find out how you can get more involved locally, contact volunteer@abta.org or call 800-886-1281

American Brain Tumor Association®

Providing and pursuing answers®