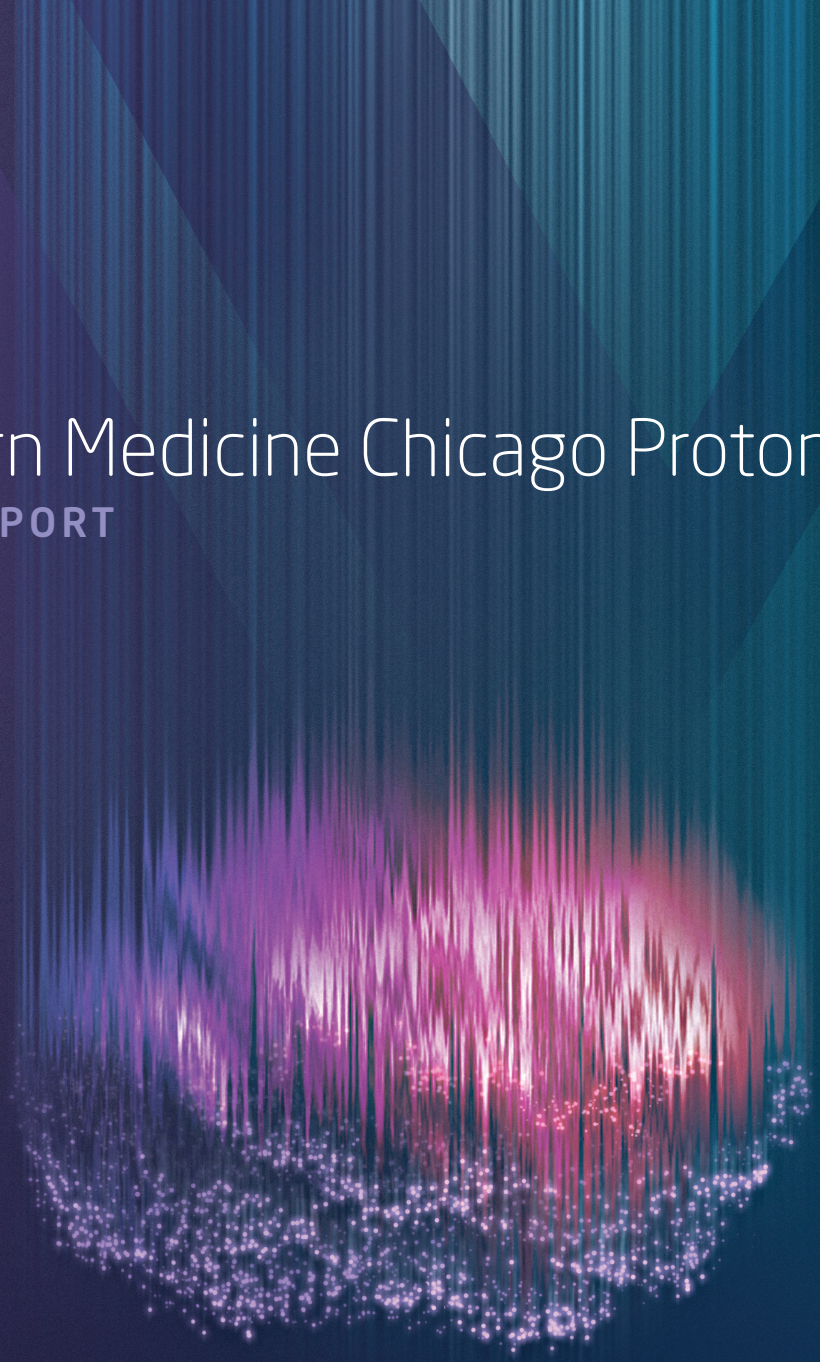
Northwestern Medicine®
Chicago Proton Center

Northwestern Medicine Chicago Proton Center

2016 ANNUAL REPORT



Technology has catapulted proton therapy treatment to the next level, advancing patient care beyond what was previously thought possible.

*The Northwestern Medicine® Chicago Proton Center (Center) is a joint venture between various Northwestern Memorial HealthCare subsidiaries and physicians of Radiation Oncology Consultants, Ltd., dedicated to providing proton therapy in Illinois. The physicians who practice at the Center are neither agents nor employees of Northwestern Memorial HealthCare nor its subsidiaries. They have chosen this facility as the place they wish to care for and treat their private patients.

Dear Colleagues:

The increased efficacy of proton therapy has been substantiated in recent years. New research confirms that proton therapy can significantly reduce the exposure of adjacent healthy tissues to radiation, minimize the chance of developing a secondary malignancy later in life and even lead to higher survival and cure rates, as compared to traditional photon or X-ray radiation. More and more physicians and their patients are turning to Northwestern Medicine Chicago Proton Center* (Chicago Proton Center) than ever before.

Three forces fuel this growth – *technology, research and collaboration*. The latest advancements in technology together with our commitment to research provides our patients with greater access to proton therapy. This type of care is a game-changer for patients with pediatric, brain/spine, breast, head and neck, lung, prostate, ocular, gastrointestinal and lymphoma cancers.

Technology has catapulted proton therapy treatment to the next level, advancing patient care beyond what was previously thought possible. Some of the newest technological advances at the Northwestern Medicine Chicago Proton Center include:

- In early 2016, Pencil Beam Scanning (PBS) was added to our gantry room, enabling us to expand the spectrum of tumors we can treat with our precision therapy.
- In October 2016, we implemented a new approach to computed tomography (CT) imaging technology for use in treatment planning that includes a vertical CT scanner. Using a custom-designed treatment chair, patient movement is minimized, allowing proton beams to be delivered more effectively.

Combined with advanced technology, *research* is the link between today's knowledge and tomorrow's cure. The Chicago Proton Center is a leading site for a range of clinical treatment trials including phase II and III trials sponsored by the National Cancer Institute (NCI). We are committed to offering all of our patients the opportunity to participate in a clinical treatment or registry trial. More than 90 percent of our current patients are on one of those trials. Some of our physicians serve as principal investigators, leading national clinical trials. Our ability to collaborate with researchers both at Northwestern Medicine and across the proton therapy community brings innovative treatment approaches directly to our patients, expanding hope and directly impacting patient care.

When we opened our doors in 2010, the Chicago Proton Center was the ninth proton therapy center in the United States. Today, with more than 25 proton centers in operation in the U.S. alone, we've assumed a leadership role in both the national and international proton therapy community. The staff of the Chicago Proton Center includes:

- President of the Proton Collaborative Group (PCG)
- Disease site committee chair for PCG
- Principal investigator of a National Cooperative Group
- Physics coordinator of a National Institutes of Health Patient-Centered Outcomes Research Institute (PCORI) study
- Chair of Radiation Oncology for the Children's Oncology Group
- Chair of an international gynecologic oncology study group

Collaboration is fuel for our ultimate goal – to improve patients' lives through proton therapy. The Chicago Proton Center now partners with cancer specialists from area hospitals, including Robert H. Lurie Comprehensive Cancer Center of Northwestern University, Loyola University Medical Center, Ann & Robert H. Lurie Children's Hospital of Chicago and Rush University Medical Center. Our clinical affiliates expand access and bring new perspectives to the Chicago Proton Center.

Working together with physicians like you and organizations across the Midwest and around the world, the Chicago Proton Center continues to pursue advancements to improve the lives of cancer patients everywhere.

If you think your patient might be a candidate for proton therapy, reach out to our intake nurses today. We look forward to partnering with you.

William F. Hartsell, MD, FACR, FACRO, FASTRO
Medical Director, Northwestern Medicine
Chicago Proton Center
Radiation Oncology Consultants, Ltd.

All About Proton Therapy

What is Proton Therapy?

Proton therapy, also called particle beam therapy, is a type of radiation treatment that uses proton particles, as opposed to photons (or X-rays), to attack and destroy cancer cells with greater precision.

Protons vs. Photons

While traditional photon, or X-ray/Intensity Modulated Radiation Therapy (IMRT) radiation has been the standard form of treatment for years, new studies show that the use of proton therapy can actually:

- Minimize the chance of developing a second cancer by 10 to 15 percent[1]
- Reduce the exposure of adjacent tissues by two to five times[2]

That's because protons enter the body and quickly target the tumor location. There is a minimal amount of radiation exposure in the entrance path of the proton beam, a peak radiation dose at the intended treatment area followed by a minimal to no "exit" radiation dose extending beyond the intended treatment area.[3] Photons, on the other hand, enter the body with a high dose or radiation and continue to shed radiation as they travel through the body and exit the other side.

[1] Levin WP, et al. Proton beam therapy. *Br J Cancer* 2005; 93:849-854

[2] Vargas CT et al. Dose-volume comparison of proton therapy and intensity modulated radiation therapy for prostate cancer. *Int J Rad Onc Biol Phys* 2008; 70:744-51

[3] Fowler JF. What can we expect from dose escalation using proton beams. *Clinical Onc.* 2003; 15(1):S10-S14.

Evaluating Your Patient: Our Commitment to You

A physician intake review meeting will evaluate your patient's diagnosis in detail to determine if he/she may benefit from proton therapy. Once the diagnosis has been reviewed, the patient will be contacted to discuss the next steps. If it is determined that your patient's diagnosis is not appropriate for proton therapy, other treatment options may be recommended.

Our commitment to you and your patient will continue even after your patient completes treatment with proton therapy.

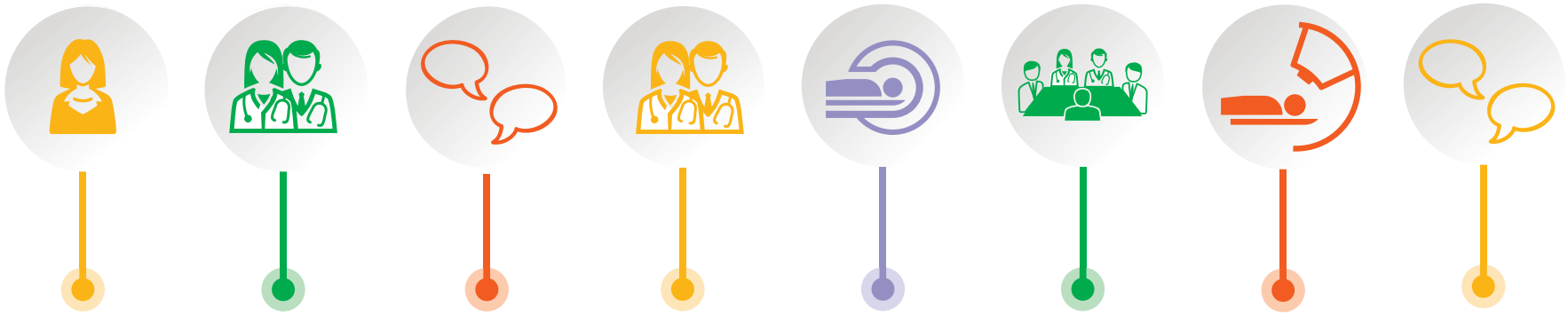
You can expect us to provide:

- Unbiased information on proton therapy
- Timely and detailed access to your patient's medical records
- Open communication with radiation oncologists before, during and after treatment
- Regular updates on the progress of your patient
- Excellent patient care based on your patient's individual needs

Who is eligible?

- Patients whose tumors are near critical organs or structures, such as the heart, lungs, brain, GI tract, prostate or spine
- Patients who cannot have additional X-ray radiation treatment
- Patients whose cancers have recurred
- Children (see Pediatric Section, page 9)

The Northwestern Medicine Chicago Proton Center Patient Journey



Patient is referred by his/her physician

Daily physician intake review within 24 hours: Is patient a good candidate for proton therapy?

Patient and proton center physician meet for in-person consult

2x weekly consult review meeting (after full workup evaluation): Is proton therapy the best treatment option for this patient?

CT scanning/ simulation: Used to create a custom treatment plan by the Center's dosimetrists—tracks tumor motion, providing a very accurate picture by pinpointing the tumor's unique shape, size and precise location

Treatment planning: Dosimetry rounds

Proton therapy treatment starts

Patient returns to referring physician for follow-up upon treatment completion

Innovation | 2016 and Beyond

Vertical CT with treatment chair

One of the challenges in radiation therapy is accounting for a patient's natural movement during the respiratory cycle. While most patients are treated with radiation in the supine or prone position, a recent study revealed a decrease in motion when patients were seated versus lying down.[4]

In October 2016, Northwestern Medicine Chicago Proton Center became the first proton center in the U.S. to treat lung tumor patients in a seated position using a designed treatment chair together with a vertical CT scanner. The new vertical CT scanner is lowered around a seated patient to capture images used for treatment planning. As a patient's lung volume opens up while seated, treatment planning and delivery can be more precise and effective, resulting in lower toxicity to lung tissue and adjacent organs.

Expansion of clinical affiliations with world-renowned local hospitals

Our commitment to collaboration begins close to home. Partnering with local hospitals and physician groups, including Robert H. Lurie Comprehensive Cancer Center of Northwestern University, Ann & Robert H. Lurie Children's Hospital of Chicago, Loyola University Medical Center and Rush University Medical Center, provides more access to proton therapy for patients across the Midwest. Our collaboration isn't limited to a referral relationship with our partners. Instead, our clinical affiliates are trained on proton therapy so they can participate in and coordinate the care of their patients while at the Chicago Proton Center.

"Prior to our work with the Northwestern Medicine Chicago Proton Center, we didn't have access to a proton center. When I thought someone might benefit from protons, I had to send patients to another physician. Now I can be involved in their treatment from A to Z. It's better for the patient and better for continuity of care when we bridge their treatment at the Chicago Proton Center," said William Small, Jr., MD, FACRO, FACR, FASTRO, Professor and Chairman, Radiation Oncology, Loyola University Medical Center.

Pencil beam scanning now on the gantry

In January 2016, we added pencil beam scanning (PBS) to the 360-degree gantry room allowing this proton modality to be delivered around the patient from an infinite amount of positions and angles. This enables us to treat a larger spectrum of tumors regardless of shape, size or location in the body with high precision at any angle, reducing the amount of treatment fields required to deliver the treatment dose. The gantry with PBS now enables the care team to treat more complex cancers such as head and neck, esophageal, brain, lung, breast and pediatric cancers where greater precision and lower toxicity to local surrounding organs are critical. PBS is rapidly becoming the standard of care in proton therapy and the Chicago Proton Center is committed to making the technology available to more patients.

Clinical trials are paying it forward

With more than a dozen clinical treatment and registry trials currently open at the Chicago Proton Center, we are taking the necessary steps today to improve the quality of life and cure rates for tomorrow's cancer patients. Participating in a number of studies that promote clinical effectiveness research, such as the Patient Centered Outcomes Research Institute (PCORI) study of women with breast cancer, NRG Oncology and Children's Oncology Group (COG) studies, we are working to better understand the effects of proton and photon radiation, minimize symptoms that accompany treatments, define optimal treatment parameters and more.

[4] Eaton BR, et al. Secondary malignancy risk following proton radiation therapy. *Front Oncol* 2015; 5:261.

Chicago Proton Center by the Numbers

CLINICAL

treat as many as
90
patients daily

We treat **5** days/week,
16 hours/day

16h

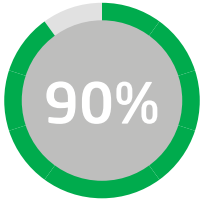
14+ clinical treatment and registry trials currently open at the Chicago Proton Center

800-2000
spots in a pencil beam scanning treatment field

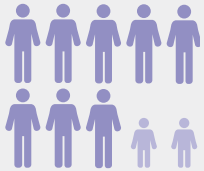
DEMOGRAPHICS

To date, our patients originated from **30** states and **14** countries

600 patients treated annually at the Chicago Proton Center



90 percent of Chicago Proton Center patients currently on clinical treatment or registry trials



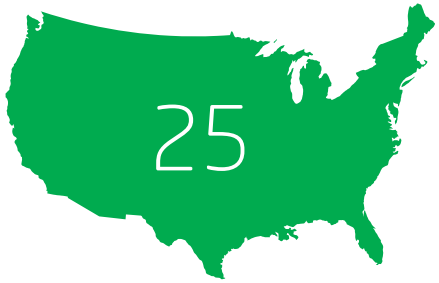
20 percent of our patients are pediatric

OPERATIONAL

6 years saving lives

The Chicago Proton Center opened in October 2010 and has treated more than 2,700 patients

9th proton center in the country



25 proton centers in the United States
55 in the world

12 more proton centers will open by 2018

FUN FACTS

400 miles/second or 2/3 the speed of light – speed at which protons move

26 Years Length of time that proton therapy has been used in a hospital setting starting at Loma Linda University in 1990

Top decile for patient satisfaction

Treating the Whole Patient

At Northwestern Medicine Chicago Proton Center, we realize our patients need more than just leading-edge cancer treatment. They also need comprehensive support. We are committed to supporting patients during treatment and beyond, with the following programs:

- **Patient Advocacy Program** provides patient advocates who help make each visit to the Chicago Proton Center a positive experience. When desired, we match up patients to others with similar diagnoses to connect and share their journey.
- **New Patient Orientation** welcomes new patients to the Chicago Proton Center family, providing information about the Center, what to expect during treatment and available resources. Informal support groups are offered for patients to meet each other and share their stories.
- **Ronald McDonald House® near Northwestern Medicine Central DuPage Hospital** provides a home away from home at no cost for pediatric proton therapy patients and their family members.
- **Patient Assistance Fund** at the Chicago Proton Center can help provide travel and lodging assistance to those who need it. Contact our patient services team for eligibility details.
- **On-Site Childlife Specialist** provides help and support for each pediatric patient throughout their treatment. A social worker and financial counselor are also available to patients and their families.
- **LivingWell Cancer Resource Center** in Geneva, Illinois, provides services free of charge to both Chicago Proton Center patients and their caregivers. Through professional-led support groups, educational workshops, nutrition classes, exercise classes and stress-reduction classes, participants can learn vital skills to help regain a sense of control, reduce feelings of isolation and discover that they're not alone.
- **Online Virtual Lobby** is the Chicago Proton Center's private Facebook page which features status updates and other announcements for our patients.
- **Graduation Ceremony** is held every Wednesday for patients who have completed treatment. The celebration ceremony is located in the building's main lobby for all to see.

LivingWell Cancer Resource Center

Pediatrics

Studies show that across the board, 80 to 85 percent of pediatric cancers are cured. However, standard X-ray radiation can leave children with devastating, long-term side effects, including physical disabilities or, in some cases, a diminished IQ. Additionally, cells and organs exposed to X-ray radiation have a two to five times higher rate of developing a second cancer later in life than those treated with proton therapy.[5]

"We've gotten so good at curing kids who have cancer that the main focus should now be on quality of life. Proton radiation gives patients the best quality of life by far over standard radiation. At Northwestern Medicine Chicago Proton Center, we're doing our best to make sure that proton therapy becomes more accessible and available."

– John Han-Chih Chang, MD, Director of Clinical Education, Northwestern Medicine Chicago Proton Center

[5] Horner MJ, Ries LAG, Krapcho M, Neyman N, Aminou R, Howlader N, Altekruse SF, Feuer EJ, Huang L, Mariotto A, Miller BA, Lewis DR, Eisner MP, Stinchcomb DG, Edwards BK (eds). SEER Cancer Statistics Review, 1975-2006. Bethesda, MD: National Cancer Institute; 2008.

Pediatrics (continued)

At the Northwestern Medicine Chicago Proton Center, we believe that every child deserves to live cancer-free, and proton therapy can be the answer. Clinical studies suggest that, due to its more targeted treatment, proton therapy can reduce the long-term side effects for pediatric patients,[6] ultimately improving a child's long-term quality of life into adulthood.

Common diagnoses treated:

- Atypical teratoid/rhabdoid tumor (AT/RT)
- Craniopharyngioma
- Medulloblastoma
- Ependymoma
- Germinoma
- Glioma
- Lymphoma of the mediastinum
- Neuroblastomas in the chest, abdomen near the spine
- Sarcoma in the head and neck, lung and rib, pelvic and bone

Typical course of treatment: Four to six weeks/20 to 30 treatments

Continuity of Care

A special pediatric clinic at the Chicago Proton Center creates continuity of care for our youngest patients. The medical staff at the Chicago Proton Center treats pediatric patients in conjunction with Ann & Robert H. Lurie Children's Hospital of Chicago, offering three points of contact:

Monday	Tuesday	Wednesday
Ann & Robert H. Lurie Children's Hospital of Chicago physicians come to the Chicago Proton Center to see their patients on proton therapy treatment	**The Tumor Board, made up of the pediatric team from Ann & Robert H. Lurie Children's Hospital of Chicago and Chicago Proton Center physicians, review current and potential cases**	**Drs. Chang and Hartsell see patients at the neuro-oncology clinic at Ann & Robert H. Lurie Children's Hospital of Chicago**

Technology

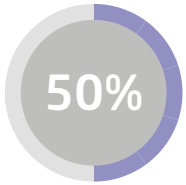
Pencil beam scanning (PBS)

With the ability to rotate treatment equipment 360 degrees around the patient, PBS (known by our youngest patients as "painting by dots") on the Gantry allows us to target pediatric tumors that were previously more difficult to treat due to their location or irregular shape.

6. Lundkvist J, et al. Cost-effectiveness of proton radiation in the treatment of childhood medulloblastoma. *Cancer* 2005;103:793-801.

Do pediatric patients receive anesthesia during proton therapy?

Children 5 years and younger typically require anesthesia when receiving proton therapy



Between 5 and 8 years old, about 50 percent of our pediatric patients require anesthesia

8+

Children 8 years and older typically don't require anesthesia

Clinical Trials

PPCR 12-103 – Registry for Pediatric Patients Treated With Proton RT: The goal of the Pediatric Proton Consortium Registry (PPCR) is to enroll children treated with proton radiation in the United States in order to describe the population that currently receives protons and better evaluate its benefits over other therapies. The data collected from this study will help facilitate research on proton beam radiation therapy and allow for collaborative research.
ClinicalTrials.gov Identifier: NCT01696721

2005P001629 – Prospective Assessment of Quality of Life (QOL) in Pediatric Patients Treated With Radiation Therapy for Brain Tumors and Non-Central Nervous System (Non-CNS) Malignancies: Through open pediatric protocols for patients treated with proton radio therapy, the investigators aim to define and report the acute and late effects associated with treatment. The aims of this study are: 1) to prospectively collect and report the QOL outcomes in patients treated with radiotherapy and 2) to correlate the QOL data with pertinent clinical information.
ClinicalTrials.gov Identifier: NCT01115777

REG001-09 – Patients Treated With Proton Therapy: A registry trial to collect and analyze information from patients treated with proton therapy.
ClinicalTrials.gov Identifier: NCT01255748

Phase I and II Pediatric Brain Tumor Consortium Group trials testing cutting edge chemotherapy and radiation options for children.

Other trials:
- Northwestern Medicine's Pediatric registry trial
- Chicago Proton Center registry trial
- Children's Oncology Group clinical trials

Head and Neck

At the Chicago Proton Center, we believe that treating cancer is about maximizing the quality of life for each patient. For those with head and neck cancers, proton therapy can help preserve the ability to perform basic functions that could be affected by traditional radiation, such as eating, swallowing and talking.[7] With the recent addition of Pencil Beam Scanning (PBS) on the Gantry, we have been able to treat the most challenging head and neck tumors with high precision.

"When treating head and neck cancers, we have to consider the many areas that contribute to major functions—eating, swallowing, talking—given how close these structures are to each other. There's always a danger of making the treatment worse than the disease. Living without any one of these functions would have a major impact on lifestyle. Proton therapy provides a better long-term quality of life for patients. As the treatment improves, the survival rate climbs."

- John Han-Chih Chang, MD, Director of Education, Northwestern Medicine Chicago Proton Center

[7] Sio at al, Intensity Modulated Proton Therapy Versus Intensity Modulated Photon Radiation Therapy for Oropharyngeal Cancer: First Comparative Results of Patient-Reported Outcomes. *Int J Rad Onc Biol Phys* 2016; 95:1107-14. Patel SH et al. Charged particle therapy versus photon therapy for paranasal sinus and nasal cavity malignant diseases: A systematic review and meta-analysis. *The Lancet Oncology* 2014; 15:1027-1038.

Studies show that the ability of proton therapy to target a tumor while avoiding surrounding tissue and organs can lead to higher survival and cure rates. A registry study completed from 2011 to 2014 in collaboration with Northwestern Medicine Chicago Proton Center, Memorial Sloan Kettering Cancer Center and Princeton's Radiation Oncology, revealed the following radiation success rates:[8]

- Proton therapy: 75 percent
- IMRT: 25 – 40 percent

Similarly, the Chicago Proton Center internal registry study of first-time radiation patients treated with proton therapy, and conducted from 2010 to 2014 found similar results, revealing an 86.3 percent survival rate after four years.

Common diagnoses treated:

Paranasal sinus cancers

Nasopharyngeal cancers

Oropharyngeal cancers (base of tongue, tonsil)

Salivary gland tumors

Typical course of treatment: Six to seven weeks/30 to 35 treatments

[8] Romesser PB, et al. Proton beam reirradiation for recurrent head and neck cancer: Multi-institutional report on feasibility and early outcomes. *Int J Rad Onc Biol Phys* 2016; 95:386-95.

Technology

Vertical CT and treatment chair

Some patients with head and neck cancer are able to breathe easier during scans and treatment when in a seated position. Because organs respond to gravity, use of the new vertical CT scanner and the Chicago Proton Center-developed treatment chair help us obtain a more accurate representation of the head and neck area during CT scans taken to plan treatment.

PBS on the Gantry

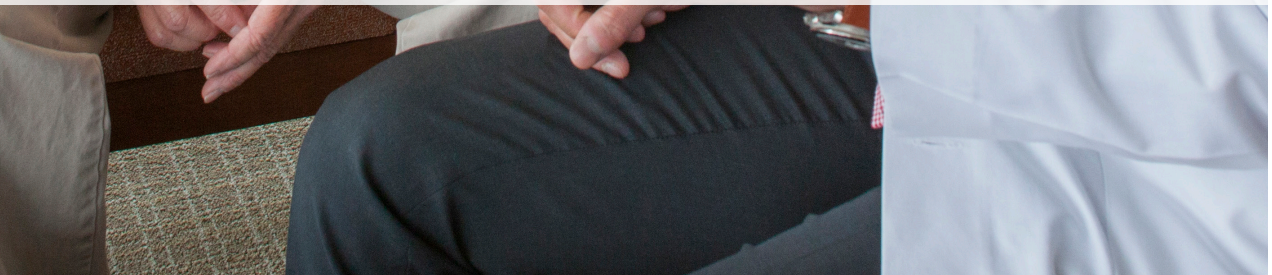
Using PBS on the Gantry, where the equipment has full, 360 degree range of motion, we can now treat both sides of the neck effectively by rotating around the patient, sparing as much healthy tissue as possible. This enables us to treat tumors even more precisely and at just about any angle, while keeping the patient as comfortable as possible.

Clinical Trial

REG001-09 – Patients Treated With Proton Therapy: A registry trial to collect and analyze information from patients treated with proton therapy.
ClinicalTrials.gov Identifier: NCT01255748

"As we learn more about the toxicity of radiation therapy, it's becoming increasingly apparent that sparing the heart and lungs as well as the esophagus may improve the patient's quality of life during the course of therapy and positively impact long-term outcomes. I think proton therapy gives us the opportunity to spare those structures better than any other modality we have now."

- Nasiruddin Mohammed, MD, MBA
Radiation Oncology



Lung

Previously it was believed that higher doses of radiation therapy would result in higher survival rates for patients suffering with lung cancer. Recent clinical trials, however, have dispelled this belief and instead revealed that patients, who received a higher dose of photon or IMRT radiation, don't fare as well as expected.[9] This is likely related to the side effects of the treatment. Exposing otherwise healthy adjacent organs, like the heart and esophagus, to unnecessary radiation may be a limiting factor, and the benefits of a higher radiation dose to the tumor were curbed as a result.

[9] Bradley J et al. Standard-dose versus high-dose conformal radiotherapy with concurrent and consolidation carboplatin plus paclitaxel with or without cetuximab for patients with stage IIIA or IIIB non-small-cell lung cancer: A randomized, two-by-two factorial phase 3 study. *The Lancet Oncology* 2015;16(2):187-93.

Proton therapy limits toxicity to adjacent organs and tissues because of its ability to deliver a higher dose more precisely at the tumor site with a small entry dose and no exit dose. This helps patients with both acute and late-stage lung cancer tolerate treatment more easily.

One of the greatest challenges in treating patients with a lung tumor is the natural movement of the lung during treatment. A number of new technologies currently in use at Northwestern Medicine Chicago Proton Center, including the vertical CT scanner and treatment chair, pencil beam scanning (PBS) and 4D CT scanning, have dramatically improved our ability to treat patients with lung tumors.

Common diagnoses treated:

Locally-advanced, non-small cell lung cancer

Stage I, II or III

Typical course of treatment:

- **Stage I – Two weeks/five to 12 treatments**
- **Stage II or III – Six to seven weeks/30 to 35 treatments**

Technology

Vertical CT and treatment chair

Ideal for treating lung and chest wall tumors, the vertical CT and Chicago Proton Center-developed treatment chair are used to make tumor location more predictable when taking scans to plan treatment and during treatment.

PBS on the Gantry and uniform scanning

Depending on the tumor size, location and stage, proton therapy can be administered via PBS on the Gantry or uniform scanning. Having both treatments available allows us to better meet the needs of each individual patient.

Clinical Trials

LUN005-12 – Phase I/II Study of Hypofractionated Proton Therapy for Stage II-III Non-Small Cell Lung Cancer: The purpose of this research study is to compare the effects (good and bad) on subjects and their cancer using standard chemotherapy in combination with hypofractionated proton radiation therapy. Hypofractionation is a technique that delivers higher daily doses of radiation over a shorter period of time.
ClinicalTrials.gov Identifier: NCT01770418

RTOG 1308 – Comparing Photon Therapy to Proton Therapy to Treat Patients With Lung Cancer: This randomized phase III trial studies proton chemoradiotherapy to see how well it works compared to photon chemoradiotherapy in treating patients with stage II and stage III non-small cell lung cancer that cannot be removed by surgery.
ClinicalTrials.gov Identifier: NCT01993810

UPCC 23309 – Recurrent Tumors: A study to determine the feasibility of using proton radiotherapy in recurrent malignancies. Patients with histologically confirmed, non-CNS solid malignancies that have been previously radiated and have a tumor recurrence in or near prior radiation fields can participate in the trial.
ClinicalTrials.gov Identifier: NCT01126476

REG001-09 – Registry Study for Radiation Therapy Outcomes: The purpose of this research study is to collect and analyze information from patients being treated with various forms of radiation therapy.
ClinicalTrials.gov Identifier: NCT01255748

Brain

With low-grade and benign brain tumors, we are improving our understanding of the cognitive side effects of radiation therapy[10] and our ability to utilize proton therapy to minimize these effects.[11,12] Ongoing efforts are focused on treating such patients, who can be young and expected to live a long time, with proton therapy to better preserve their cognitive function and quality of life.

"Based on recent trial results, patients with low-grade glioma are being treated earlier in their disease course and at an earlier age, when preventing cognitive side effects can have a profound impact on their quality of life. In this context, proton therapy may play an important role in the treatment of such patients, and as a result we have seen an increase in the number of low-grade glioma patients we treat at the Northwestern Medicine Chicago Proton Center."

- Vinai Gondi, MD, Director of Research, Northwestern Medicine Chicago Proton Center

10. Gondi V, et al. Hippocampal dosimetry predicts neurocognitive function impairment following fractionated stereotactic radiotherapy for benign or low-grade adult brain tumors. *Int J Radiat Oncol Biol Phy,* 2011; 83: e487-493.
11. Sherman JC, et al. Neurocognitive effects of proton radiation therapy in adults with low-grade glioma. *J Neurooncol* 2016;125(1):157-64.
12. Shih HA, et al. Proton therapy for low-grade gliomas: Results from a prospective trial. *Cancer* 2015; 121:1712-1719.

Proton therapy plays an important role in treating recurrent brain, skull base and spine tumors that may require a second course of radiation therapy. Proton therapy, with its unique ability to target the recurrent tumor with a large dose of radiation while simultaneously minimizing dose to the previously irradiated adjacent tissues, can help prevent potentially devastating complications from re-irradiation.

Common brain cancer diagnoses treated:

- Glioma—low-grade or previously irradiated recurrent
- Chordoma
- Chondrosarcoma
- Ependymoma
- Medulloblastoma
- Meningiomas—atypical/malignant or previously irradiated recurrent

Typical course of treatment: Six weeks/30 treatments

Technology

Treatment chair

The Chicago Proton Center cranial treatment chair has been in use for the simulation and treatment of brain tumors for three years. In addition to keeping the patient more comfortable, the chair minimizes patient movement during treatment.

PBS on the Gantry

For brain tumors, PBS on the Gantry provides the greatest conformity to minimize neurotoxicity. When used to treat atypical/malignant meningiomas, for example, which involve the lining around the brain, patients can be rotated in 360 degrees to allow for any number of treatment angles. This allows for precise proton beam treatment that spares adjacent tissue.

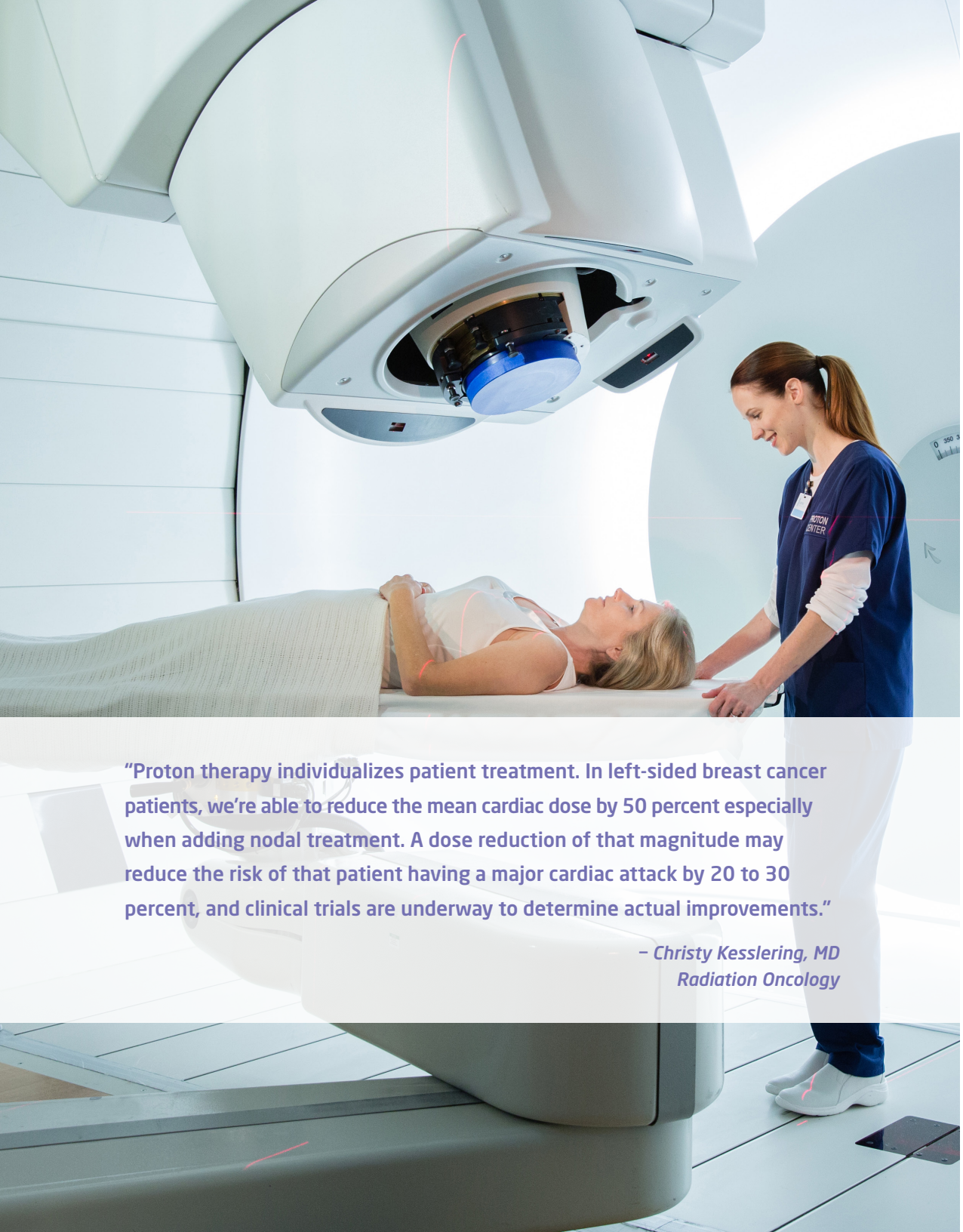
Clinical Trials

NRG BN001 – Dose-Escalated Photon IMRT or Proton Beam Radiation Therapy Versus Standard-Dose Radiation Therapy and Temozolomide in Treating Patients With Newly Diagnosed Glioblastoma: This randomized phase II trial studies how well dose-escalated photon intensity-modulated radiation therapy (IMRT) or proton beam radiation therapy works compared with standard-dose radiation therapy when given with temozolomide in patients with newly diagnosed glioblastoma. Dr. Gondi is principal investigator. This trial is currently closed to new patients.
ClinicalTrials.gov Identifier: NCT02179086

NU 11C02 – Efficacy of Hypo-Fractionated XRT w/Bevacizumab + Temozolomide for Recurrent Gliomas: This phase II trial studies how well giving hypo-fractionated radiation therapy together with temozolomide and bevacizumab works in treating patients with high-grade glioblastoma multiforme or anaplastic glioma.
ClinicalTrials.gov Identifier: NCT01478321

RTOG 1205 Bevacizumab With or Without Radiation Therapy in Treating Patients With Recurrent Glioblastoma: This randomized phase II trial studies how well bevacizumab with or without radiation therapy works in treating patients with recurrent glioblastoma.
ClinicalTrials.gov Identifier: NCT01730950

REG001-09 – Registry Study for Radiation Therapy Outcomes: The purpose of this research study is to collect and analyze information from patients treated with various forms of radiation therapy.
ClinicalTrials.gov Identifier: NCT01255748



"Proton therapy individualizes patient treatment. In left-sided breast cancer patients, we're able to reduce the mean cardiac dose by 50 percent especially when adding nodal treatment. A dose reduction of that magnitude may reduce the risk of that patient having a major cardiac attack by 20 to 30 percent, and clinical trials are underway to determine actual improvements."

– Christy Kesslering, MD
Radiation Oncology

Breast

Standard photon radiation used to treat breast cancer runs the risk of long-term side effects due to low-level irradiation of the adjacent healthy tissues and organs, including the heart, lung and contralateral breast—especially when incorporating lymph nodes close to the breast. Proton therapy can deliver up to four times less dose to local organs and tissues because it stops at a prescribed depth in the tissue and delivers minimal to no exit dose.[13] This is particularly exciting in locally advanced, left-breast cancer patients where lymph nodes need to be treated, as radiation in these cases comes within just a few millimeters of the heart.

[13] Ares C et al. Postoperative proton radiotherapy for localized and locoregional breast cancer: Potential for clinically relevant improvements? *Int J Rad Onc Bio Phys* 2010; 76:685-697.

Similarly, for right-breast cancer patients, proton therapy reduces related complications, as normal tissues adjacent to the breast or chest wall will be spared, reducing the potential for long-term side effects including coronary artery disease, lung scarring and secondary malignancies.[14]

Common breast cancer diagnoses treated:
Locally advanced, lymph node-positive breast cancers

Typical course of treatment: Six weeks/30 treatments

Technology

PBS on the Gantry

PBS on the Gantry offers a completely new approach to treating breast cancer. This technology:

- Delivers a more homogenous/uniform dosing distribution to the breast tumor
- Can decrease the dose in the skin, resulting in less acute skin reaction
- Provides better conformity to the tumor, allowing us to spare even more dose to the heart and lung than with a uniform scanning plan
- Decreases radiation delivery time to the breast by more than 50 percent

[14] Rubino C, et al. Radiation dose and risk of soft tissue and bone sarcoma after breast cancer treatment. *Breast Cancer Res Treat* 2005;89:277-288. Deutsch M, et al. The incidence of lung carcinoma after surgery for breast carcinoma with and without postoperative radiotherapy: Results of National Surgical Adjuvant Breast and Bowel Project clinical trials B-04 and B-06. *Cancer* 2003; 98:1362-1368.

Clinical Trials

NCT02603341 – Pragmatic Randomized Trial of Proton vs. Photon Therapy for Patients With Non-Metastatic Breast Cancer: A Radiotherapy Comparative Effectiveness Consortium Trial. A pragmatic randomized clinical trial of patients with locally advanced breast cancer randomized to either proton or photon therapy and followed longitudinally for cardiovascular morbidity and mortality, health-related quality of life and cancer control outcomes. Quality of life is the outcome measure for the estimated primary completion date of November 2020.
ClinicalTrials.gov Identifier: NCT02603341

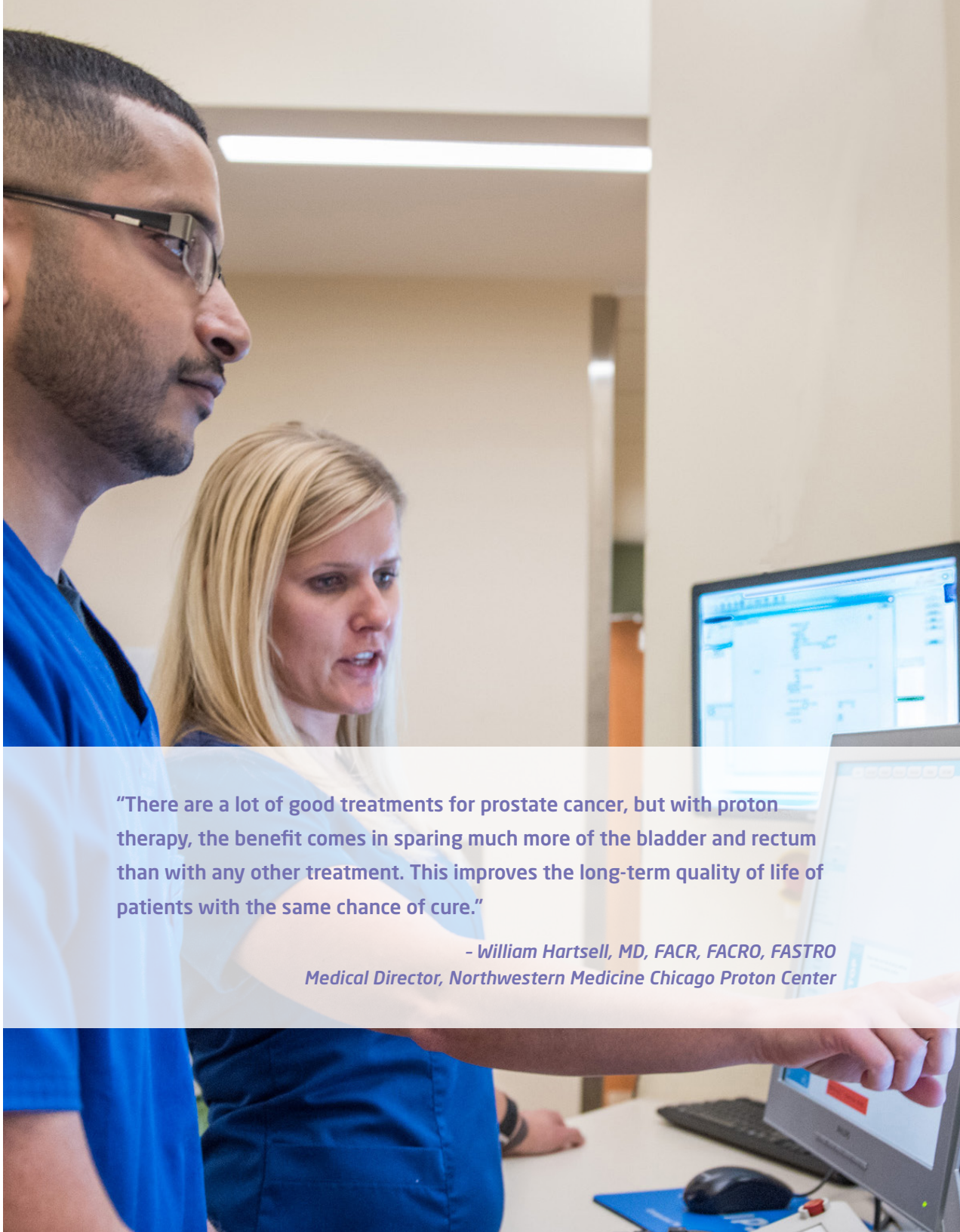
BRE007-12 – Phase II Protocol of Proton Therapy for Partial Breast Irradiation in Early Stage Breast Cancer: The purpose of this research study is to compare the effects (good and bad) on women and their cancer using proton radiation therapy.
ClinicalTrials.gov Identifier: NCT01766297

BRE008-12 – Proton Radiation for Stage II/III Breast Cancer: The purpose of this study is to look at the rates of acute and long-term adverse events of post-operative proton radiotherapy for complex logo-regional irradiation in women with loco-regionally advanced breast cancer. This study specifically includes longitudinal follow-up to assess the incidence of cardiac mortality and second malignant neoplasms at 10 and 15 years following proton therapy.
ClinicalTrials.gov Identifier: NCT01758445

REG001-09 – Patients Treated With Proton Therapy: A registry trial to collect and analyze information from patients treated with proton therapy.
ClinicalTrials.gov Identifier: NCT01255748

Prostate

A prostate tumor is typically slow-growing. Therefore, prostate cancer patients may find that multiple treatment options are available to them, including careful monitoring without immediate treatment. For this reason, the Chicago Proton Center maintains a number of patients on active surveillance who repeat PSAs and tumor biopsies on a bi-annual and annual basis respectively, to determine if and when proton therapy is the right option for them. Patients with other local complications, like ulcerative colitis and Crohn's disease, benefit greatly from proton therapy because less of the bowel is treated with proton beams as compared to photon or X-ray radiation.



"There are a lot of good treatments for prostate cancer, but with proton therapy, the benefit comes in sparing much more of the bladder and rectum than with any other treatment. This improves the long-term quality of life of patients with the same chance of cure."

- William Hartsell, MD, FACR, FACRO, FASTRO
Medical Director, Northwestern Medicine Chicago Proton Center

New research reflects the efficacy of proton therapy for patients with low, intermediate and high-risk prostate cancer. The study reports excellent biochemical control rates, while also preserving quality of life and a low incidence of high-grade urologic toxicity after five years.[15]

Other research suggests that shortened courses of radiation therapy may deliver the same outcome for patients with prostate cancer. At the Chicago Proton Center, we are testing this hypothesis in a trial that delivers five treatments over the course of one week, instead of the typical 39 to 44 treatments, spread over eight to nine weeks.

Common prostate cancer diagnoses treated:	
Stage I	Stage IIB
Stage IIA	Stage III

Typical course of treatment (depends on stage and other factors):

- **Over two weeks/five treatments**
- **Over five-and-a-half weeks/28 treatments**
- **Over eight to nine weeks/44 treatments**

Clinical Trials

GU002-10 – Study of Hypo-Fractionated Proton Radiation for Low Risk Prostate Cancer: The purpose of this study is to compare the effects (good and bad) on patients with prostate cancer by comparing the standard dose of radiation therapy (44 treatments over eight-and-a-half to nine weeks) with a higher daily dose of radiation (five treatments over one to two weeks) to see if the effects of the treatments are similar or better.
ClinicalTrials.gov Identifier: NCT01230866

GU003-10 – Hypo-Fractionated Proton Radiation Therapy With or Without Androgen Suppression for Intermediate Risk Prostate Cancer: The purpose of this study is to compare the effects (good and bad) of two treatment methods on subjects and their cancer, namely the use of hypofraction proton therapy (28 treatments) alone to proton therapy with androgen suppression therapy.
ClinicalTrials.gov Identifier: NCT01492972

11-497 – Proton Therapy vs. IMRT for Low or Intermediate Risk Prostate Cancer (PARTIQoL): In this research study, we are comparing IMRT to proton beam therapy to determine which therapy best minimizes the side effects of treatment for men being treated for prostate cancer.
ClinicalTrials.gov Identifier: NCT01617161

Registry Study for Radiation Therapy Outcomes: A registry trial to collect and analyze information from patients treated with proton therapy.
ClinicalTrials.gov Identifier: NCT01255748

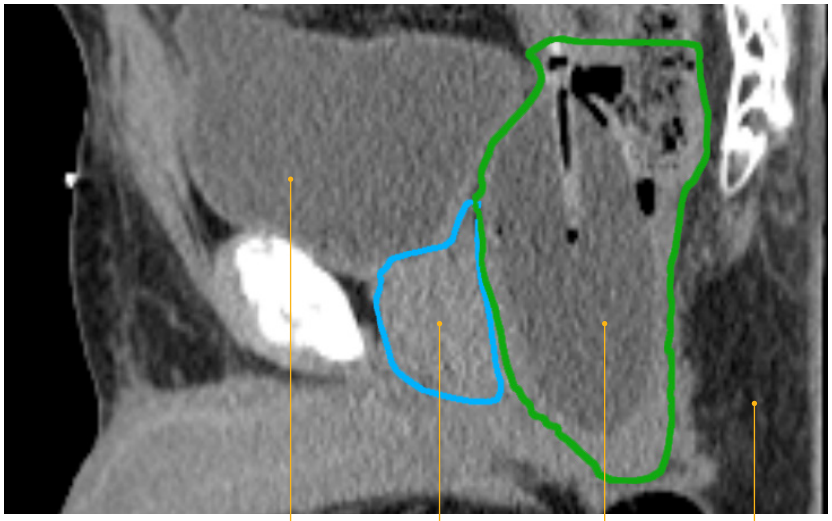
[15] Bryant C, et al. Five-year biochemical results, toxicity, and patient-reported quality of life following delivery of dose-escalated image-guided proton therapy for prostate cancer. *Int J Radiat Oncol Biol Phys* 2016; 95:422-434.

Prostate (continued)

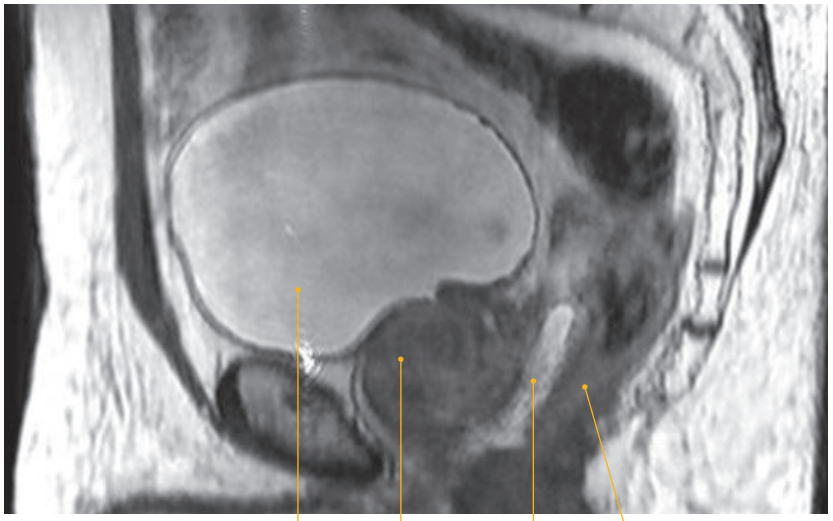
When we initially opened in 2010, we used the rectal balloon technique for prostate patients to reduce rectal toxicity and prostate motion during proton therapy treatment. This technique meant patients had a rectal balloon inserted before each treatment. With bringing the latest advancements in technology to our patients as one of our top priorities, we now use the SpaceOAR® hydrogel technique when treating most prostate patients.

Treatment Comparison

Rectal Balloon Spacer



Biodegradable Hydrogel Spacer



Technology

Hydrogel spacer

The Chicago Proton Center uses SpaceOAR hydrogel to further reduce the risk of rectal injury in men receiving prostate cancer radiation by acting as a spacer – pushing the rectum away from the prostate during treatment. The hydrogel, which is injected into the patient during a one-time minimally invasive procedure, remains in the patient for the three-month cycle of radiation before it's absorbed.

Pencil beam and uniform scanning

We use multiple techniques for treatment of prostate cancer. The technique selected depends on the patient's unique anatomy. All of the treatments use scanned proton beams, either with uniform scanning or pencil beam scanning.

Other Cancers Treated

Other Cancers Treated	Common Diagnosis	Typical Course of Treatment
Eye Collaborating with multiple ophthalmologists throughout Illinois and Wisconsin, the Northwestern Medicine Chicago Proton Center has achieved remarkable success at treating ocular melanomas, resulting in a 95 percent cure rate. A more attractive alternative to eye removal or plaque/brachytherapy, particle therapy for ocular melanomas is easier on the patient and may result in better tumor control and lower complication rates.[16]	Ocular melanomas	One week/five treatments
Gastrointestinal Because of their location within the body, gastrointestinal cancers will typically require a combination of treatment modalities, including surgery, chemotherapy and radiation. Working together, the patient's oncologist and the Chicago Proton Center radiation oncologist will determine if proton therapy is the right option. For liver and bile duct cancers, where higher doses of radiation are required for cure, it is difficult, if not impossible, for photon radiation to meet the dosimetric requirements. This is due to the constraints of normal tissue tolerability and a patient's existing complications, such as hepatitis. Proton therapy is especially positioned to cure in these cases because of its ability to deliver a more powerful, targeted radiation. Similarly, for patients with pancreatic cancer, treating with proton therapy either pre- or post-operatively results in more precise delivery of the required radiation dose to the pancreas. Without an exit dose, proton therapy spares the bowel and stomach effectively, reducing nausea and vomiting and increasing the likelihood that patients will receive the full course of treatment with minimal weight loss.	Liver/bile duct cancers Pancreatic cancer Stomach cancer Esophageal cancer	**Liver tumors** Three weeks/ 15 treatments **Other GI tumors** Six weeks/ 30 treatments
Lymphoma For Hodgkin's lymphoma patients, a typical treatment regimen of chemotherapy followed by radiation can carry a high cure rate. In these cases, minimizing radiation-induced side effects is critical to providing a greater long-term quality of life. The lower incidence and severity of toxicity to adjacent organs – the heart, lung and breast – with proton therapy can help patients live with fewer long-term, radiation-induced side effects, such as heart attack, heart failure, lung cancer and breast cancer.	Hodgkin's lymphoma	Three to five weeks/five treatments per week

16. Mishra KK el al. Long-term results of the UCSF-LBNL randomized trial: Charged particle with helium ion versus iodine-125 plaque therapy for choroidal and ciliary body melanoma. *Int J Radiat Oncol Biol Phys* 2015; 92:376-383.

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The Northwestern Medicine® Chicago Proton Center (Center) is a joint venture between various Northwestern Memorial HealthCare subsidiaries and physicians of Radiation Oncology Consultants, Ltd., dedicated to providing proton therapy in Illinois. The physicians who practice at the Center are neither agents nor employees of Northwestern Memorial HealthCare nor its subsidiaries. They have chosen this facility as the place they wish to care for and treat their private patients.

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