



Proton Radiation for Tumors in the Brain: a Family Connection

In the records of the department of radiation medicine at Loma Linda University Health, it is not uncommon to find patients who are members of the same immediate or extended family. It is unusual, however, to encounter two patients from the same family who were treated for two different types of brain lesions. That is the case, however, with Jennifer Gardner and Cheryl Bellerose, both of Redlands, California.

In 1997, when she was a teenager, Jennifer received proton therapy for an astrocytoma of the cerebellum and brain stem. She had symptoms that included headache, vomiting and some unsteadiness in walking. She and her family consulted surgeons, including a pediatric neurosurgeon at Loma Linda University Children's Hospital, and learned that the tumor was inoperable. She did require several surgical procedures to relieve hydrocephalus (fluid in the brain), including by means of a ventriculoperitoneal (VP) shunt. Her case was referred to the department of radiation medicine.

Jennifer was seen by two radiation oncologists then at Loma Linda, one a specialist in pediatric oncology and the other a specialist in brain tumors. They decided that she was a candidate for proton therapy because her tumor, although causing distressing symptoms, was localized. She was treated in the spring of 1997.

Between proton therapy and her surgical procedures (nine altogether),

Jennifer improved quickly. She says that she had no side effects from proton treatment and, in fact, pursued vigorous athletic activities during proton treatment, including cross-country running, swimming and surfing. Follow-up examinations showed complete regression of her tumor and at this writing, 16 years later, she no longer needs to be followed regularly.

Jennifer says that one of her main recollections of proton therapy at Loma Linda was the superb team spirit she encountered among the radiation oncologists, nurses and radiation therapy technologists she met in the department of radiation medicine. As an athlete herself, she appreciated this spirit, which included her as the patient. The feeling of all working together toward a successful treatment outcome was strong, so much so that, Jennifer says, it eventually altered her own life plans: she wanted to be part of the medical environment too.

Today Jennifer works at Loma Linda University Health. She is a medical assistant in the emergency department at Loma Linda University Medical Center. She also

works for American Medical Response as an emergency medical technician (EMT) and, at this writing, is seeking certification as a flight medic. She continues to be a highly active, athletic young woman.

In 2002, Cheryl Bellerose began to experience unexplained dizziness. She went to her doctor, who referred her to a neurologist. A work-up revealed that she had an acoustic neuroma, a benign tumor of the auditory nerve. Cheryl was referred to a surgeon, who recommended an operation. Cheryl did check out several options, including centers in Los Angeles.

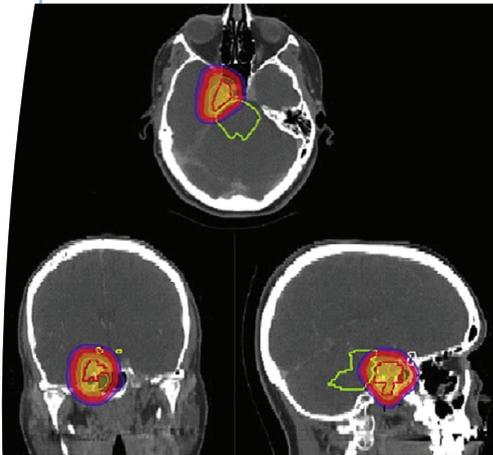
Cheryl, however, remembered her younger cousin, Jennifer. At that time Jennifer was already five years past proton treatment for a malignant brain tumor and was doing very well. This encouraged Cheryl to wonder whether protons could be used for her case as well; she inquired, and was seen by Dr. Lilia Loredo in the department of radiation medicine.

Dr. Loredo examined Cheryl and her records, including CT scans. She told Cheryl she was confident that proton therapy could be used successfully in her case; Cheryl



Cousins Jennifer Gardner (left) and Cheryl Bellerose (right)

felt confidence in Dr. Loredo's judgment. Cheryl then began a six-week treatment course of 30 fractions of proton radiation therapy. She says she experienced no side effects from treatment and, more importantly, no loss of hearing, either from the tumor or as a side-effect of radiation treatment.



*Isodose distribution of cavernous sinus meningioma treated with four proton beams. Colored lines show dose from the beams; red indicates the highest dose, blue, the lowest. Note that most of the brain receives no radiation. The ragged green line represents the brain stem, most of which is also avoided by the proton beams. From Slater JD, Loredo LN, Chung A, Bush DA, Patyal B, Johnson WD, Hsu FP, Slater JM. Fractionated proton radiotherapy for benign cavernous sinus meningiomas. *Int J Radiat Oncol Biol Phys.* 2012;83:e633-637.*

At the time she was treated, Cheryl worked at the School of Dentistry on the Loma Linda University Medical Center campus. "My treatments were easy," she says. "I worked right next door, so every day I would walk over to the hospital, get my proton therapy, and walk back to work." Cheryl says she felt very comfortable with the treatment setting and personnel in the department of radiation medicine.

"I loved the Christian atmosphere," she says; "it was a good place to be."

Cheryl has since retired from her job at the School of Dentistry. She and her husband love to travel and live an active life,

seeing various places and hiking in the nearby mountains. Today, 11 years after her last proton treatment, she needs follow-up visits only every three years.

The family connection in Cheryl and Jennifer's cases goes on. Two of their uncles have received proton radiation therapy for cancer of the prostate.

Proton Therapy for Tumors of the Central Nervous System (CNS)

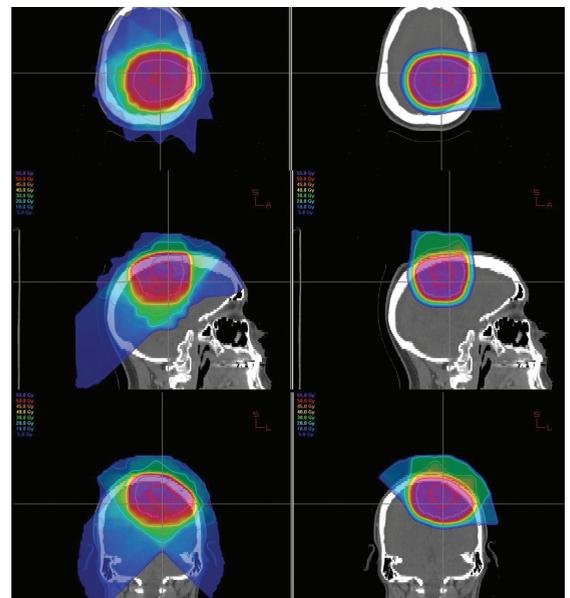
In many respects, Jennifer's and Cheryl's situations were different: Jennifer had a malignant tumor that required several surgical interventions before and during proton therapy; Cheryl had a benign tumor that was discovered early. In both cases, however, their treatments called for radiation to the brain, and in both cases protons offered a way to deliver that radiation without irradiating other parts of the brain.

Sparing tissue that does not need to be irradiated is what proton therapy is all about. Because the beam can be conformed so closely to the volume that needs to be irradiated, Dr. Loredo and other radiation oncologists in the department of radiation medicine can deliver the high doses needed to control the tumor without causing radiation damage to nearby brain tissue. This is always important, but especially so when treating in the brain and even more so when treating children, whose tissues are still developing.

Both Cheryl and Jennifer reported no side effects from proton therapy. Both continued to lead active lives during treatment. This was made possible by the tissue-sparing capabilities of proton therapy. Although needed conformal doses of radiation can be delivered to brain volumes with modern forms of x-ray therapy such as IMRT, surrounding tissue cannot be spared from lower doses of radiation, as is the case with protons. It is this ability to spare tissue that helped prevent hearing loss in Cheryl's case, and development problems in Jennifer's.

The reason that proton therapy is so advantageous in treating tumors in the brain and in children comes down

to simple physics. Protons have mass; photons, the fundamental particles of x-ray beams, do not. Accelerated protons, therefore, are much less likely to scatter in tissue than photons are, so they can reach the target volume using fewer beams than are needed for photons. Further, protons do not release the bulk of their energy until they stop in the targeted tissue; at that point, they release all of their energy and no tissue beyond the target is irradiated. Photons release energy all the way to the target and past it. Taken together, these are the physical reasons that protons can spare normal tissue to a much greater extent than is possible with photons. The differences in dose distribution between proton and photon beams often are dramatic.



*Comparing treatment plans using intensity-modulated X-ray therapy (left) and proton radiation therapy for a 35-year-old patient with a history of seizure from a grade II oligodendroglioma. Tumor location prevented complete surgical removal. The proton plan spares the greatest volume of normal tissue. From Gridley DS, Grove RS, Loredo LN, Wroe AJ, Slater JD. Proton-beam therapy for tumors of the CNS. *Expert Rev Neurother* 2010 Feb;10(2):319-330.*

Dr. Loredo, who treated Cheryl and treats many of the CNS patients at Loma Linda University Health, perhaps describes the proton advantage best. "We want to destroy the tumor and allow normal tissues to keep functioning normally. The best way to do both is to conform the dose to the tumor cells and leave the rest alone."