Loma Linda's Beam of Hope: A First for Cancer Therapy

by W. Clark Davis

January 1, 1990, will mark the opening of Loma Linda University Medical Center's Proton Beam Therapy System, the world's first clinically based charged-particle accelerator facility designed to treat cancerous tumors. The facility's opening will mark the fruition of a cooperative effort by researchers at Loma Linda, Harvard University, the University of California at Berkeley, Los Alamos National Laboratory, the National Cancer Institute, the Swiss Institute of Nuclear Research, Science Applications International Corporation, and several other research institutions around the world to use charged-particle radiation for cancer treatment. These researchers believe that Loma Linda's proton accelerator, presently under construction at the Fermi National Accelerator Laboratory (Fermilab) in Batavia, Illinois, will revolutionize cancer therapy.

During the past two decades Loma Linda has invested heavily to develop the necessary equipment and staff to operate a charged-particle facility. Now that the technology is available, Loma Linda is committed to developing and building the $40 million accelerator and its housing facility. The institution's investment in infant heart transplantation research has proved enormously fruitful. Now Loma Linda again hopes that study and diligent medical research and preparations will inaugurate a new era in another field of scientific medicine.

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Not all elements in the university's constituency have been pleased by the vast financial commitment Loma Linda has made to the project. In a time of financial retrenchment for the university and medical center, some in the local constituency question any new large expenditure. With talk of campus unification and the selling of some of the university's holdings, suspicions have circulated that these proposals are efforts to raise money for the proton accelerator. In response to continual allegations to this effect, the medical center board has reiterated its long-standing commitment that no money for the project will be allocated from the sale of university holdings.

Grumblings have also been heard among some physicians in the medical center that the department of radiation sciences, which will run the proton accelerator, has been the recipient of a disproportionate share of the medical center's resources. Those involved in the project, however, argue that once it is understood what proton therapy will mean to the university and to medical science, the entire constituency will rally around the project. Medical center and university administration assert that to remain competitive and viable, they must be on the cutting edge of new scientific technology. They unequivocally vow to commit the institution to areas in which Loma Linda can assume a leading international role. Infant heart transplantation and proton therapy are examples of two such commitments. Many others could be cited.

The proton-beam therapy Loma Linda will employ is a result of 40 years of effort on the part of scientists to make radiation a dramatically

more viable treatment for cancer. Radiation is known to be an effective cancer treatment, able to destroy most cancerous tissue when given in sufficient doses. However, two factors have hindered its effectiveness. First, it has been difficult to locate the precise site and extent of tumors to which radiation should be administered. Second, under traditional cobalt beam or x-ray treatments, the dose of radiation needed to destroy tumors also affects the healthy tissue surrounding the cancerous site, often causing intolerable side effects. Thus, even when radiation oncologists could precisely locate the site of the tumor, they often could not irradiate it with the needed dose without damaging surrounding healthy tissue. The result is that the dose of radiation given a patient often is less than what is needed to destroy the tumor. It is estimated that 100,000 Americans die each year because their localized cancer is not totally removed or destroyed.

In this decade, advances such as computerized tomography (CT scans) and magnetic resonance imaging (MRI scans) have solved the problem of mapping tumors. These instruments allow physicians to determine the precise definition and location of tumors. The marvel of the proton beam is that it allows physicians to deliver radiation directly to a specific point, predetermined by the accelerated energy of the beam, with minimal effect on the healthy tissue surrounding the growth. Thus, with the use of proton beams, scientists can deliver doses of radiation strong enough to destroy tumors without affecting other tissues and causing crippling side effects.

The use of proton beams to destroy tumors within healthy tissues was first proposed by Robert Wilson in 1946 while he was at the Lawrence Berkeley Laboratories. His comments sparked a flurry of scientific interest in charged-particle radiation. Eventually, 13 charged-particle, high-energy physics laboratories were constructed and patient trials begun. These laboratories, including the Berkeley Radiation Laboratories, the Harvard Cyclotron Laboratory, and the Los Alamos National Laboratory, are all designed for physics research, yet currently all but Los Alamos treat cancer patients. The results have been uniformly positive, with success rates ranging from 85 to 95 percent on some of the localized tumors that are more difficult to treat. Because of the design configuration and other demands of these facilities, however, clinical and medical research is severely limited.

Loma Linda's involvement with proton beam therapy began in 1971 when Dr. James Slater and others at the university, frustrated by the limitations of traditional radiation therapy, turned to the idea of a charged-particle therapy facility as the best hope for cancer treatment. Slater then began what has been 17 years of meticulous effort to prepare the way for a proton therapy facility at Loma Linda.

Loma Linda began participating with the Berkeley particle-beam studies in the early 1970s and has remained closely tied with research at the Berkeley Laboratories ever since. Loma Linda staff were also involved in particle-beam research at the Los Alamos National Laboratory in New Mexico until 1982, when President Reagan's budget cuts closed the facility.

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As Loma Linda staff were gaining clinical experience in the use of particle beams for cancer therapy, the university was acquiring and developing equipment and technology that would ultimately be needed to run a particle-beam facility. Among the significant preparations made at Loma Linda was the development of a CT computer-assisted planning system that provided the basis for the serious pursuit of a clinically based, particle-beam accelerator.

Loma Linda has also been steadily recruiting a team of physicists, physicians, engineers, and computer experts trained in the uses of charged-particle radiation. At present, Loma Linda has already assembled the requisite number and quality of personnel needed to run the facility.

By 1984, Dr. Slater felt that worldwide technology and cancer biology were sufficiently advanced to plan for a proton beam therapy system. He then organized a group of approximately 100 physicists, engineers, and physicians who first met in January 1985 at Fermilab to discuss the possibility of designing a clinically based charged-particle therapy system. They called themselves the Proton Therapy Cooperative Group. One year later, the Fermilab administration, the University Research Association—which guides the operation of Fermilab—and the U. S. Department of Energy, which owns Fermilab, all agreed to build a clinical proton accelerator for Loma Linda, which in turn promised to finance the venture and operate the facility.

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With other universities already operating charged-particle laboratories, many have queried how Loma Linda became the first institution to develop a medically dedicated facility. According to Philip Livdahl, then deputy director of Fermilab, "No one picked them. They singled themselves out." Dr. John Glancy of Science Applications International Corporation applauded Loma Linda as "a sponsor that had the courage to be first." A review of Loma Linda's proposals to establish the facility makes it clear that Dr. Slater and his colleagues worked for nearly two decades to bring hospital-based proton therapy to Loma Linda. Loma Linda's radiation oncologists convinced their department and institution years ago that proton therapy, what they like to refer to as a "beam of hope," would one day provide a dramatic new treatment for those suffering with cancer. Loma Linda's proton therapy facility will be the visible tip of a mountain of research efforts at Loma Linda and around the world.

Construction of the proton beam facility began in April and has proceeded on schedule. The medical center is going to extreme lengths to ensure that the facility is completed by its scheduled opening date in 1990. Construction of the 250 million electron-volt proton synchrotron is well underway at Fermilab. The accelerator is expected to be completed this year in order to allow for a period of testing.

The treatment facility at Loma Linda will be a 250,000-square-foot complex located on the southeast corner of the medical center. It will house four treatment rooms, two operating rooms for administering radiation during surgery, and one room for research in radiobiology and proton physics. Loma Linda anticipates that the center will treat more than 1,000 patients a year.

The total cost of the venture is roughly $40 million, yet Loma Linda's bill has been cut in half as the U. S. Department of Energy rallied the federal government to support the project. Twenty million dollars has been committed by the Department of Energy, approved by Congress, and signed into law by President Reagan, although until the president signed the final allocation in early August, there was some question as to whether the money would be forthcoming. While the news media made fun of various pet projects in the budget bill, the money for Loma Linda's proton accelerator was often questioned in newspaper and magazine stories.

Of the remaining $20 million, Loma Linda University Medical Center has already contributed roughly $12 million. The medical center plans, however, to recoup this cost and raise the remaining $8 million through a massive corporate fund-raising drive. Augustus Cheatham, vice-president for public relations at the medical center, believes the money will be easily raised. He states, "In a time of budget reductions, the proton accelerator project captured the mind of the U. S. Congress, which immediately put forth half of the cost for the entire project. Finding others willing to contribute to the project has been equally easy and the funding campaign is now actually ahead of schedule."

Financial concerns no longer trouble those at Loma Linda, for they believe the project's ramifications will extend far beyond their earliest hope. Loma Linda anticipates the facility will become a self-supporting, National Cancer Institute-approved regional cancer center for the four California counties that the Loma Linda University Medical Center serves.

A cooperative association of the Adventist Health Systems hospital network for cancer patient care and professional education is also planned. The facility will also become the primary international center for cancer research with proton-beam therapy, including clinical and basic studies. To varying degrees, every department within the school of medicine, as well as many of the undergraduate physical and biological science departments, are expected to become involved with this technology.

Scientists from other universities and national agencies, such as the National Aeronautics and Space Administration, have expressed strong interest in cooperative research efforts with this new facility. The university hopes to develop master's and doctoral programs in radiation physics. Finally, by owning the patent on the Fermilab-constructed proton synchrotron, Loma Linda will be able to continue developing advancements in charged-particle therapy and will remain a guiding force behind proton therapy for many years to come.

Some 80 years since its establishment as a sectarian medical sanitarium, Loma Linda is now pinning two decades of investment and its reputation on scientific research and treatment in the belief that proton therapy will provide those diagnosed with localized cancers a simple and effective cure.