GammaKnife Radiosurgery at Swedish Medical Center

D. Marshall Davis, MD

Stereotactic radiosurgery (SRS) utilizes therapeutic radiation in a novel fashion by combining many narrow "pencil" beams arrayed from multiple directions, precisely focused on a small target. This allows the absorbed radiation dose to be deposited at this focal intersection point while simultaneously minimizing dose deposition in surrounding non-target tissues. Dr. Lars Leksell initially developed this technology in Sweden and the first dedicated device to perform SRS was the GammaKnife in 1967. Initially devised to substitute for standard neurosurgery within inaccessible regions of the brain, it is now considered a standard therapy option for a variety of medical conditions.

Dr. Marshall Davis is a board-certified radiation oncologist and has been a member of the CyberKnife team at Newport Diagnostic Center since 1994. After earning his medical degree from the University of Nebraska, Dr. Davis completed his internship at Denver Presbyterian Medical Center and his residency at University of California, San Francisco Medical Center. His extensive experience includes serving as clinical assistant professor at the University of Southern California School of Medicine. He was also department director for radiation oncology at Century City Hospital and Sonora Cancer Center.

Introduction. Stereotactic radiosurgery (SRS) utilizes therapeutic radiation in a novel fashion by combining many narrow "pencil" beams arrayed from multiple directions, precisely focused on a small target. This allows the absorbed radiation dose to be deposited at this focal intersection point while simultaneously minimizing dose deposition in surrounding non-target tissues. Dr. Lars Leksell initially developed this technology in Sweden and the first dedicated device to perform SRS was the GammaKnife in 1967. In its current configuration, the GammaKnife deposits radiation utilizing a fixed arrangement of 201 isocentrically positioned, non-opposing 60Co y-beams, each with a nominal energy of 1.25 MeV. The distribution of these is in a hemispheric fashion such that a halo or "crown" of radiation is deposited resulting in dose clouds with a roughly spherical or ellipsoid shape. These small clouds of dose, referred to as "shots" are adjusted for volume by varying the size of standard available collimators and can be clustered together so as to create dose distributions that conform tightly around small targets. Initially devised to substitute for standard neurosurgery within inaccessible regions of the brain, it is now considered a standard therapy option for a variety of medical conditions.

The indications for radiosurgery continue to expand, with a list that includes both benign and malignant tumors of the brain, encompassing primary gliomas as well as metastatic lesions, arteriovenous malformations and functional conditions such as trigeminal neuralgia. Although SRS was not widely accepted in the United States until the late 1980's, it has been incorporated rapidly into the armamentarium of treatment options for these medical conditions. Swedish Medical Center has had an established radiosurgery program for 5 years utilizing a linear accelerator based technology. This X-Knife incorporates our standard 6 MV energy linear accelerator outfitted with special equipment mounted to the gantry head in order to perform the SRS procedures. With this system, the radiation is deposited within a precisely determined collection of intersecting arcs distributed around the targeted region. Again, the optimizing process strives to conform radiation dose tightly around the intracranial target.

The majority of radiosurgical devices use an invasive fixed head frame for immobilization to achieve the accuracy necessary for treatment delivery, although newer technologies utilize implanted

fiducials which can be tracked in real time by cameras, robotically manipulated small linac beams which track skull position in real time (CyberKnife) or relocatable headframes which typically utilize a bite block system. With all these technologies, the treatment goal is typically to deliver a single, large radiation dose to the target so as to take advantage of the radiobiological advantages inherent in this strategy (the explanation of which is beyond the scope of this article).

The GammaKnife is still considered the "gold" standard for radiosurgery delivery, and we at Colorado Neurological Institute and Swedish Medical Center are fortunate to soon have this device available for our patients. We look forward to building on the initial experience of our linear accelerator-based program. To ensure the success of this endeavor, our effort will include active marketing as well as extensive education to surrounding communities and physicians both to increase awareness of the potential utility of the GammaKnife as well as to illustrate how this device has changed the paradigm in which we think of particular illnesses.

There is abundant literature describing the use of GammaKnife to treat benign tumors including acoustic schwannoma, meningioma, craniopharyngioma and both secreting and non-secreting pituitary adenomas. Within the CNI Brain Tumor Program we are excited about its potential utility in treating astrocytoma and oligodendroglioma, both primary and recurrent. The "paradigm shift" I discussed is particularly evident for brain metastasis which makes up between 50 percent and 70 percent of individual GammaKnife treatments worldwide. Historically, the overall survival for patients with brain metastasis was as little as 2 months with a mean of 4 to 6 months, with the use of corticosteroids and standard whole brain radiotherapy. This contrasts with the recent experience gained at multiple radiosurgical centers in which patients with good performance status are approached with SRS or surgical metastasectomy followed by whole brain radiotherapy, or in specific instances, observation without radiation in the hopes of sparing toxicity. Selected patients followed in this fashion have survivals of 18 to 24 months or longer. The goal is to maximize control of central nervous system disease for the lifetime of the patient and with the advent of newer and improved systemic therapies for metastatic cancer, we project ever-increasing survivorship of these patients. The recurring theme in treatment is to maximize and maintain quality of life, function, and, when possible, longevity.

Conclusion. The cost of GammaKnife compares favorably with other modalities such as standard surgery, conventionally delivered radiation and other anti-cancer therapies. It is also the most cost effective SRS system as compared to an adapted linear accelerator, providing the volume of patients seen is adequate. We anticipate build out and construction to begin with installation by the end of October, 2004. Acceptance testing will follow and with this in mind, we will look forward to the planned dedication of our GammaKnife facility later this year. Please join us at that time.

Address comments and questions to:
D. Marshall Davis, MD
Swedish Medical Center
Department of Radiation Oncology
799 E. Hampden Avenue, Suite 100
Englewood, CO 80113