Gamma Knife

This information is reviewed by a physician with expertise in the area presented and is further reviewed by committees from the American College of Radiology (ACR) and the Radiological Society of North America (RSNA), comprising physicians with expertise in several radiologic areas.

What is this equipment used for?

The gamma knife and its associated computerized treatment planning software enable physicians to locate and irradiate relatively small targets in the head (mostly inside the brain) with extremely high precision. Intense doses of radiation can be given to the targeted area(s) while largely sparing the surrounding tissues. The gamma knife can be used for a wide variety of problems. For example, it can be used to treat selected malignant tumors that arise in or spread to the brain (primary brain tumors or metastatic tumors), benign brain tumors (meningiomas, pituitary adenomas, acoustic neuromas), blood vessel defects (arteriovenous malformations) and functional problems (trigeminal neuralgia). Possible future uses are being evaluated for epilepsy and Parkinson's disease.

The gamma knife is usually unsuitable for targets larger than three or four centimeters in size.

How does the equipment work?

The gamma knife utilizes a technique called stereotactic radiosurgery, which uses multiple beams of radiation converging in three dimensions to focus precisely on a small volume, such as a tumor, permitting intense doses of radiation to be delivered to that volume safely. Current models of the gamma knife use advanced robotic technology to move the patient in submillimeter increments during treatment, to focus radiation successfully to all parts of the target. Gamma knife treatments are given in a single session.

Under local anesthesia, a special rigid head frame incorporating a three-dimensional coordinate system is attached to the patient’s skull with four screws.

Imaging studies, such as magnetic resonance imaging (MRI), computed tomography (CT), or angiography are then obtained and the results are sent to the gamma knife's planning computer system. Together, physicians (radiation oncologists and neurosurgeons) and medical radiation physicists delineate targets and normal anatomical structures and use the planning computer to determine the exact relationship between them and the headframe and calculate gamma knife treatment parameters. Targets often are best treated during the treatment session with combinations of several successive aimings, commonly known as "shots." The physicians and physicists routinely consider numerous fine-tuning adjustments of treatment parameters until an optimal plan and dose are determined.

Using the three-dimensional coordinates determined in the planning process, the frame is then precisely attached to the gamma knife unit to guarantee that when the unit is activated, the target is placed exactly in the center of approximately 200 precision-aimed, converging beams of (Cobalt-60 generated) gamma radiation. Treatment takes anywhere from several minutes to a few hours to complete depending on the shape and size of the target and the dose required. Patients do not feel the radiation. Following treatment the headframe is removed and the patient may return to normal activity.

Who operates this equipment?

A multidisciplinary team approach provides patients with the greatest safety. The team is most commonly comprised of a radiation oncologist, a medical radiation physicist and a neurosurgeon—all specially trained in the use of the gamma knife—with support from nursing staff, anesthesiologists (for patients who are unable to cooperate, such as children) and radiation therapists, who work together to provide patients with the high-quality care they deserve.

How is safety ensured?

Because placement accuracy of the shots is critical to localization of the radiation (to a fraction of a millimeter) anything that would degrade this precision is unacceptable. Rigid attachment of the headframe, geographic targeting accuracy of the imaging studies, shaping of the volume of tissue to be treated (selection of the number, size and relative intensity of the shots) and accuracy of attachment of the frame to the gamma knife unit are all critical. As is true of all radiation therapy, correct selection and calculation of the amount of radiation to deliver are essential. A qualified medical physicist assures that the imaging and treatment planning computers and software are correct and acceptable. The mechanical functions of the machine are tested on a regular basis to ensure the safety of patients and medical staff.