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Planning the Gamma Knife Unit

The Gamma Knife Center of the Carolinas

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Dallas

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In today's healthcare environment there are many treatments in the fight against cancer. Chemotherapy, surgery, radiation therapy, and bone marrow transplants are all recognized procedures used by physicians to battle the debilitating disease. One of the more recent advances in cancer treatment is radiosurgery. Radiosurgery involves irradiating a brain tumor with a dose of precisely directed radiation that is delivered such that surrounding tissue is not damaged. One instrument used to perform radiosurgery is the gamma knife unit.

Many hospitals are considering a gamma knife center as an addition to their existing nuclear medicine programs. With this addition come many interrelationships and programmatic requirements that must be addressed. Hospital infrastructure, potential campus sites, intradepartmental relationships, and increased patient stress all play an important role in locating these new centers and developing the programs for the center's design. All these factors were addressed in developing South Carolina's only gamma knife center.

The Gamma Knife Center of the Carolinas successfully integrates into the existing campus while maintaining critical spatial relationships. The facility brings together the need for a high-tech medical environment with the patient's need for a warm, safe treatment experience through a well-developed space plan and the center's proximity to necessary support spaces. Through careful programming and the need to create a patient-friendly environment, innovative solutions were achieved to bring daylight into the unit and provide an efficient facility for both staff and patients alike.

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In an age when technology is advancing faster than man is capable of adapting to it, it is refreshing to come across a relatively old technology, by today's standards, that is gaining momentum in the never-ending fight against cancer: the gamma knife. The gamma knife was the first radiosurgical instrument, operated in Sweden in 1968. Lars Leksell, a Swedish neurosurgeon, developed the concept in 1951. Today it is one of the most precise radiosurgical devices physicians are using to battle cancer tumors in the brain once thought to be inoperable.

Figure 1. Gamma knife unit

With fewer than 50 gamma knife centers located throughout the United States, the gamma knife still represents an attractive addition to many nuclear medicine programs. With new facilities being planned, the following paper will attempt to address some of the architectural and planning issues that must be resolved in the development of these facilities and give a recent gamma knife center project as a successful case study.

The Process

The gamma knife is a stereotactic radiosurgical device used in the treatment of brain tumors and arteriovenous malformations, as well as to relieve pain associated with trigeminal neuralgia. It enables very precise surgical changes to be made within the brain without the risks of conventional surgery or radiation therapy. It works by delivering, in a single treatment session, 201 beams of cobalt-60 radiation to a single, focused point on the targeted brain lesion. This causes distortion of the DNA mapping of the cells, destroying their ability to replicate. Each individual beam of the gamma radiation is relatively harmless to the surrounding tissue it passes through. It is only where the beams focus that a high dose of radiation is achieved to destroy targeted cells. Gamma knife treatment takes effect immediately and is believed to be as effective as conventional neurosurgery for some cases, and more effective in others, making gamma knife radiosurgery a very attractive alternative to conventional neurosurgical treatments.

Treatment is planned and administered by a staff specially trained in the use and limitations of the gamma knife unit. The treatment team typically includes a neurosurgeon, a radiation oncologist, a medical physicist, a registered nurse, and a

radiation therapist.

A typical patient day consists of the patient arriving and having the frame applied to his or her head. Once the frame is attached, the patient is sent to imaging, where an MRI, CT scan, or angiography may be administered depending on the illness. The target is localized and its x, y, and z coordinates determined relative to the frame. The IMAGES are transferred directly to dosimetry, where the patient's treatment is planned. Once the treatment is planned, the patient is laid on the couch of the gamma knife unit. Treatment lasts from 15 minutes to several hours depending on the complexity of the treatment plan and the number of doses required. When the treatment is complete, the frame is removed and the patient discharged. The whole process may take as little as five or six hours.

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Planning

Many considerations go into the planning and integration of a gamma knife suite into the existing hospital system. Local demand for the service, hospital infrastructure, and site availability, as well as minimizing the overwhelming feelings of high technology for the patients, are all issues that begin to shape the facilities program and locate the facility within the hospital campus.

Local demand for gamma knife treatment, in conjunction with its use as an inpatient or outpatient service, will help to structure the program, dictating number and sizes of prep/holding rooms, nurse stations, and procedure-planning facilities. Calculations of utilization are based on population, historical incidence of the tumor in the population, and historical percentage treatable with the gamma knife. Once the potential treatable cases are calculated for the service area, the hospital can calculate the projected annual usage of the facility. This information allows the hospital to establish operational models that affect the size and relationships of the spaces within the suite.

In cases where patients will receive the treatment and then be held overnight, the preparation area might be only a space that can be closed off with a cubicle curtain, with patients waiting in their individual patient rooms between imaging and treatment. At the other extreme, when the service is entirely outpatient, the preparation area also takes on a holding function, and additional space may be required for family waiting.

There are intradepartmental considerations that need to be addressed. Since the treatment involves a radiation oncologist, a medical physicist, and a radiation therapist, locating the gamma knife suite in the hospital's cancer treatment department is essential. Not only is its location here convenient for staff who will be using the facility, the gamma knife program will have greater access to the cancer department's medical library, laboratory facilities, and other medical staff specializing in treatment of cancer patients. Being located with other cancer treatment programs might enable sharing of support spaces among the existing programs. These shared spaces might include nurse stations, prep/holding rooms, soiled and clean utility, patient toilets, and changing and waiting areas.

Another factor to consider in siting the gamma knife suite involves the gamma knife's proximity to diagnostic imaging facilities. Being close to the imaging department cuts down on transit time and helps reduce stress for the patient.

One of the most critical factors affecting the location of the gamma knife suite is the equipment itself. The gamma knife unit weighs approximately 20 tons and is fixed to the floor at five

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points. This creates increased structural requirements for the floor that supports the unit. In addition, the dynamic loads of simply moving the unit to its final location in the hospital may make many potential sites infeasible. In approximately five to seven years the radioactive source will need to be replaced in the gamma knife unit. This involves bringing a 13-ton loader into the treatment room. This loader is used to exchange the spent cobalt-60 capsules in the gamma knife unit with new source capsules.

Shielding of the treatment room may also be a critical factor in siting the gamma knife suite. With normal-density concrete, wall thickness varies from 12" behind the unit to 18" or more at the front of the unit. Ceiling thickness is approximately 18". There may be shielding considerations for the floor as well.

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The Gamma Knife Suite

Once the site is selected, and the functional relationships between the new facility and existing departments are established, the requirements of the various rooms must be addressed. A gamma knife suite consists of several core spaces. The arrangement may vary according to site conditions, but the basic relationships between the spaces remain consistent.

There is a patient preparation area where the frame is fixed to the head of the patient prior to imaging and treatment and where the patient will be stabilized after the treatment. This space should be close to the treatment room and with as much separation from the planning area as possible.

The radiosurgical procedure occurs in the treatment room. This is where the gamma knife unit and helmet table are located. The gamma knife utilizes several differently configured 500-lb helmets to provide accurate targeting. When not in use, these helmets are stored on a helmet table inside the treatment space. Two special considerations in the arrangement of the treatment room are the need for its providing direct access to the control room and the location of the doors to the room outside the radiation cone of the unit. Minimum room dimensions and shielding requirements, as indicated earlier, will make this space the driving factor in most gamma knife facility planning. The control area contains all the instrument controls and alarms, the emergency shut-off, and audiovisual communications with the patient in the treatment room. The radiosurgical procedure is operated and supervised from the gamma knife control panel located in this space. The space needs to provide direct access to the treatment room and should be located near dosimetry.

Dosimetry is the space where the radiosurgical procedure is planned. The digital IMAGES made by MRI, CT scan, or angiography are sent directly to gamma knife planning stations in this space. It is here that the physicist and neurosurgeon carry out three-dimensional planning of the doses, the dose rate, and the lesion configuration.

Other space requirements follow the Guidelines for Design and Construction of Hospital and Health Care Facilities, published by The American Institute of Architects Press. Typical support spaces include a nurse station, soiled utility, clean supply, toilets, dressing areas, offices, and waiting area.

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Gamma Knife Center of the Carolinas: A Case Study

The Gamma Knife Center of the Carolinas is located on the Palmetto Richland Memorial Hospital campus in Columbia, South Carolina. The hospital is a 649-bed tertiary regional medical center that also serves as a teaching hospital associated with the University of South Carolina. Also located on the campus is the Center for Cancer Treatment and Research (CCTR), a freestanding 72-bed cancer center. The Gamma Knife Center of the Carolinas is the only gamma knife installation in North or South Carolina. Its market share encompasses Mecklenburg County, North Carolina, which includes the Charlotte metropolitan area, and Augusta, Georgia.

Figure 2. Site plan

The Gamma Knife Center at Palmetto Richland Memorial Hospital is located along the front façade of the hospital, situated between the main hospital and the Center for Cancer Treatment and Research. This site was chosen for its direct connection to CCTR, where all the cancer treatment and research programs and their support spaces are located, and the close proximity of the diagnostic imaging suite located on the second floor of the main hospital. It also permitted the one-story addition's location on grade so that installation of the equipment and future radiation source reloading could be easily accommodated.

Figure 3. One-story Gamma Knife Center addition

The 6,259-square-foot project consisted of 1,900 square feet of new addition; the remainder of the square footage comprised renovations to both the CCTR and the main hospital. The charge given the architect was to create an addition that would appear to have been part of the original buildings. A new one-story precast concrete bay was added to the CCTR to match an existing one-story bay, part of the original construction, on the opposite side of the building. The result is to make the CCTR façade appear symmetrical from the front of the hospital. The remainder of the new addition steps back from the precast and was clad in a curtain wall system that matches the existing four-story building connector, which connects the main hospital with the CCTR. The curtain wall system of the new addition was chosen so that from a distance this portion of the addition virtually disappears. The building was situated so that an existing staff entrance would also serve as a secondary entrance to the gamma knife suite.

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The Center for Cancer Treatment and Research is the front door to the Gamma Knife Center of the Carolinas. From the main lobby, patients and their families are directed to wait in the CCTR's main waiting room. The staff benefits from being in the CCTR, since most of their offices are in the building. There is a medical library dedicated to the treatment of cancer, as well as a host of nationally acclaimed cancer researchers and other medical colleagues who can be called upon as needed.

As previously indicated, the site also affords a close relationship to the hospital's diagnostic imaging facilities, located on the second floor of the main hospital. To reach the existing diagnostic imaging suite on the second floor of the main hospital, a new hydraulic elevator was added to an existing abandoned elevator shaft. This elevator brings gamma knife patients from the main corridor on the first floor (150' from the gamma knife center) directly in to the imaging suite on the second floor of the main hospital.

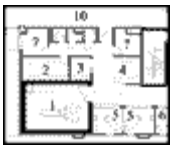

Figure 4. Floor plan and legend

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The patient flow that was originally planned involved escorting patients from the CCTR's main waiting room by a gamma knife staff member and entering the gamma knife center through the door on the east side of the stair. The patient would enter the patient dressing room before being brought to the first exam room, where the frame would be attached to the patient's head. Once the patient had been prepared and the frame attached, he or she would be assigned one of two holding rooms to await imaging and treatment.

As the staff began working in the facility, it became apparent there was no visual control of the planned entrance door into the suite. When patients entered the suite through this door, there was not a sense of arrival. There is not a good view of the prep/holding rooms from this location; you cannot see the nurse station; and it is easy for the patient to get disoriented, since there are no landmarks. As a result, what was to have been the "back door" leading to imaging has become the main door to the suite.

Figure 5. Nurse station with prep/holding rooms beyond

By entering through this door, the economy and simplicity of the suite's layout can quickly be discerned. Patients can see the prep/holding rooms directly in front of them. The nurse station is in front to the left; the treatment room to the right. The skylight floods the open space with a soft, warm light, heightening the sense of arrival while creating a node about which the remainder of the spaces in the suite are organized. By seeing all the spaces they will occupy during their treatment in one glance, patients tend to remain oriented with their environment, which helps to alleviate some of the anxiety associated with being in a strange place and having a high-tech medical treatment.

Figure 6. Front of nurse station with door to treatment open beyond

Special attention was given to the prep/holding rooms. Originally, the plan called for three prep/holding rooms to be set up identically. During the schematic design phase, a shift in thought led to the first prep/holding room, the one farthest from the treatment room, being changed to accommodate frame application and storage. The millwork in the space was increased accordingly to accommodate frame storage. The thought was that since two rooms would handle the projected short-term volume, the operational flow of the suite could be improved by

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having one location outfitted to apply the head frames. The frame room still provides the flexibility of a third prep/holding room when patient volumes increase.

Figure 7. Patient prep/holding rooms

When the gamma knife center began treating patients, it became apparent that it was much more efficient to attach the frame in the prep/holding room assigned to the patient. As patients are traveling from across the state to reach the center for treatment, and some of the physicians commute to the facility to treat the patients, the frame room has become a space the doctors can use for follow-up exams and consultations.

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The two prep/holding rooms have great visual control from the nurse station. Hospital curtains cover the doors as privacy is needed or desired. There is also an ICU breakaway door that separates the two rooms. Usually closed off with a curtain for privacy, this door provides flexibility in the rooms' uses depending on the acuity of the patients. Clean storage is accommodated in the millwork within each of the prep/holding rooms.

The architects provided floor-to-ceiling windows in each of the prep/holding rooms and the consultation/exam room. Not only does this help with the healing environment of the space, but they also serve to keep patients oriented with their surroundings within the hospital campus.

The nurse station forms the hub of the entire suite. From here there is excellent visual control over patients in the two prep/holding rooms directly opposite. The consultation/exam room is visible from the nurse station, and the station allows constant visual monitoring of the door to the treatment room. From the nurse station, one can observe what is happening in the control room through the cased opening and its side windows. This was provided to allow staff at the nurse station to view operation of the treatment, aiding in a quicker response should an emergency situation arise.

From the corridor outside the patient prep/holding rooms and through the lead-lined doors of the treatment room itself, the nurse station acts as a point of reference, keeping the patient oriented within the suite.

Figure 8: Gamma knife unit with nurse station beyond

The treatment room layout is simple and uncluttered. The gamma knife unit is approached from the rear. Along the wall is the helmet table, which supports four helmets and all the plugs used in adjusting the emission of the gamma rays for the treatment. During treatment, communication with the patient is by microphone and video camera.

In the vinyl composite tile floor pattern are angled lines that indicate the emission pattern of the gamma radiation when the unit is in operation. This abrupt change in color provides a visual boundary, informing staff in an emergency where the highest concentrations of gamma radiation have occurred.

Fluorescent perimeter lights around the space provide general illumination for the treatment room. This keeps the light out of

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patients' eyes as they are lying on their back for the treatment. Task lights, used when the helmet is changed on the unit and when a patient's frame is attached to the helmet, are provided by several dimmable incandescent lights mounted in a gypsum board barrel vault centered over the gamma knife unit. As the patient's treatment may last from 15 minutes to over an hour, the barrel vault provides visual relief from the typical flat ceilings of treatment spaces.

A cased opening was provided for the control room. The opening, coupled with the large window, helps to open up an otherwise small, confined space.

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Dosimetry is located down a corridor, somewhat away from the main traffic of the suite. This is the location where the neurosurgeon and medical physicist plan the treatment procedure.

One of the many challenges of the project was to provide for accommodation of the gamma knife unit's loader in seven years when it becomes necessary to change the cobalt-60 radioactive source. One option would have been to use the existing connector to bring the loader into the suite. This, however, would have required extensive structural upgrades to the floor system of the connector that provides a basement level connection from the main hospital to the CCTR. It also would have required a larger entrance to the suite, which was already limited in available floor area, to accommodate the space program required.

The best solution seemed to be to provide a roof hatch in the suite through which the loader could be lowered and then lifted out of once the task was complete. To capitalize on the fact that we had to provide a hole in the roof of the suite, it was decided to enclose the opening with a removable barrel-vaulted skylight that would bring warm, dynamic daylight into the very heart of the suite.

Figure 9: Building section through vaulted, removable skylight

The skylight and shaft are sized to accommodate the gamma knife loader when reloading becomes necessary. The great depth of the well minimizes the amount of direct sunlight that strikes surfaces within the suite, creating a warm, soothing glow of indirect sunlight that bathes the floor in front of the treatment room and cascades gently over the wood bullnose trim on the front of the nurse station. As a patient's procedure is concluded, and they turn to exit the treatment room, they see the daylight pouring in from the skylight just beyond the door, drawing them out into the warmth of natural light. What was initially a functional component necessary for the operation of the suite has become one of the most compelling elements of this healing environment.

Through careful planning to create a functional, efficient plan, and the desire to design a patient-friendly, healing environment, the Gamma Knife Center of the Carolinas at Palmetto Richland Memorial Hospital is a success. By listening to the owner and the users, the design team was able to pull together the spatial program required and maintain the necessary relationships between the individual parts of the suite and the hospital as a

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whole.

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Robert M. Clark, MD-Neurosurgeon
Curtis Worthington, MD-Neurosurgeon

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Figure 2
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Figure 3
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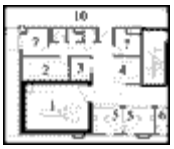
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Figure 1: Gamma knife unit. Photo: © Brian Dressler Photography

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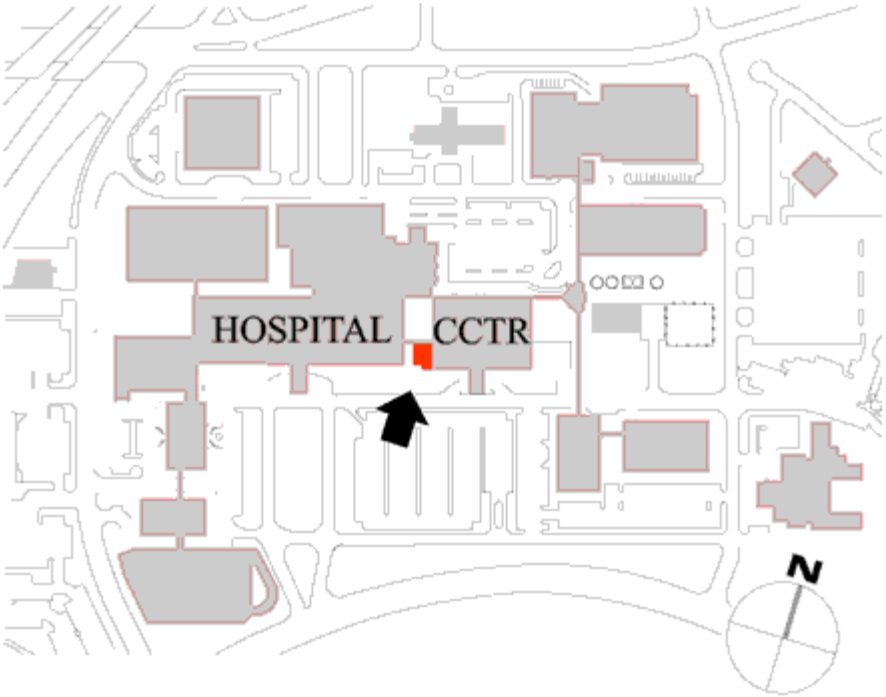

Figure 2: Site plan

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Gamma Knife Center
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Figure 3: One story Gamma Knife Center addition. © Brian Dressler Photography

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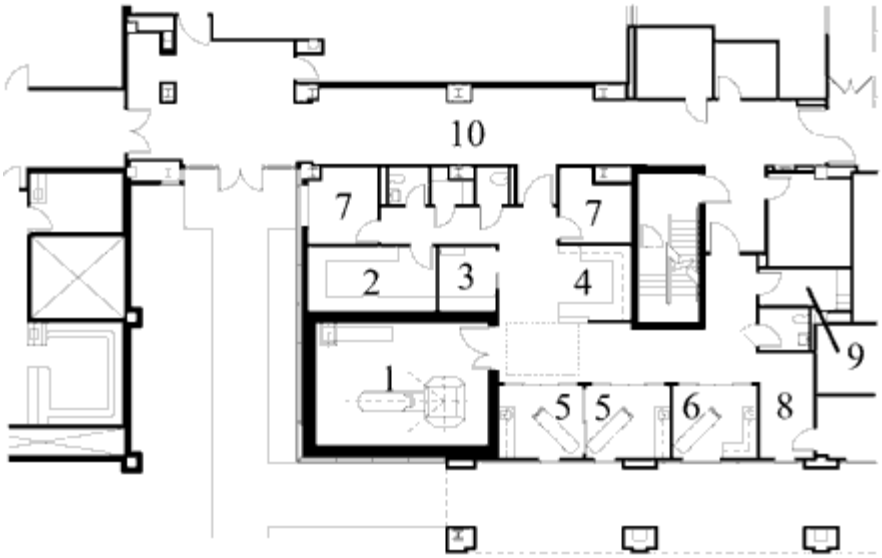

1. Treatment Room
2. Dosimetry
3. Control
4. Nurse Station
5. Prep.Holding
6. Consultation/Exam
7. Office
8. Sub-waiting
9. Patient Dressing
10. Existing Connector

Figure 4: Floor plan and legend. © Brian Dressler Photography

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Gamma Knife Center
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Figure 5: Nurse station with prep/holding rooms beyond. Photo: © Brian Dressler Photography

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Figure 6: Front of nurse station with door to treatment open beyond. Photo: © Brian Dressler Photography

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Gamma Knife Center
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Figure 7: Patient pre/holding rooms. Photo: © Brian Dressler Photography

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Gamma Knife Center
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Figure 8: Gamma Knife Unit with nurse station beyond.
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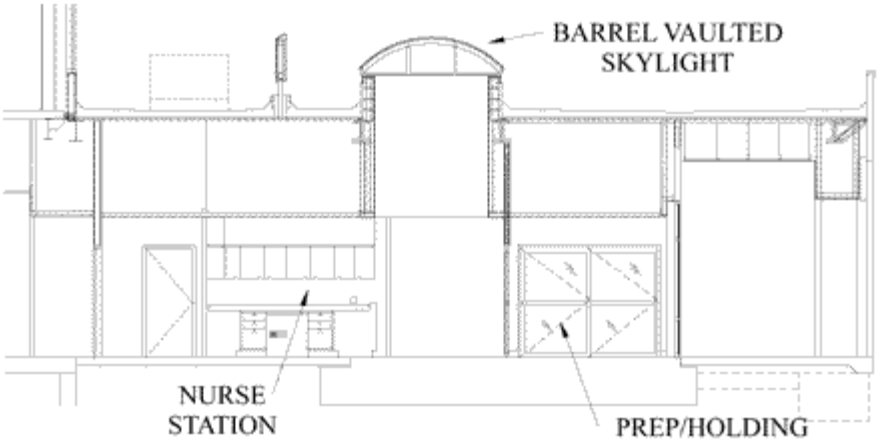

Figure 9: Building section through vaulted removable skylight

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