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MRI Suite Design

Include safety, functionality and patient comfort considerations when planning new MRI facilities.

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2013 Trend Report: Magnetic Resonance Imaging

Magnetic resonance imaging, or MRI, is a powerful diagnostic tool for today's medical practitioners. New advances in scanner technology are increasing the breadth of MRI's applications at a rapid pace, and the number of scanning suites has exploded in the past decade. Due to the immense technical complexity of MRI systems, these suites can be challenging to design, but certain strategies can help reduce dangers to patients and staff while increasing functionality, throughput, patient comfort and visual appeal.

Safety First

Planners of MRI suites should follow the planning guidelines developed by the American College of Radiology (ACR). Addressing the potential danger of ferrous items brought inadvertently into the scan room, the ACR has developed recommendations for a multi-zone design plan for MRI suites, which aims to set up increasingly restricted occupancy zones as the patient moves from the unregulated public zone outside of the suite to the most highly restricted zone of the scan room itself.

Starting at the entry to the MRI suite, Zone I of the ACR guidelines consists of the areas which are freely accessible to the public, including reception and waiting areas. Patients are then escorted into Zone II, which consists of dressing, screening and pre-scan preparation areas. Zone III consists of the passage connecting Zones II and IV, which includes the control room manned by the MR technician. Finally, Zone IV consists of the scan room itself. Overlaid on these four zones are a series of policies and procedures and, where possible, the installation of specialty ferrous metal detectors (designed specifically for use in an MRI suite) as a second line of defense,

to make sure no ferrous objects are inadvertently brought into the scan room where they would present a danger to patients and staff alike.

Location

Thought should be given to the location of the MRI suite within a building.

To begin with, remember that the MRI installed today likely will be replaced at some time in the not-too-distant future, so it is important to consider not only the route of the equipment into the space, but also the eventual route of the equipment out of the space. Because of its size, MRI equipment does not fit through ordinary doors-it often requires a large opening through an exterior wall, potential rigging through an elevator shaft, potential removals and replacement of architectural and engineering construction along the path of travel, and potential reinforcement of the floor along the path of travel. These issues may require the involvement of a specialized medical equipment rigger, the elevator maintenance company and a structural engineer. And remember to plan for the eventual replay of the above when the equipment is removed and replaced in the future.

Engineering Upgrades

The potential requirement for infrastructure upgrades is an important issue unto itself, in terms of impact on project budget and schedule. This issue can be a major factor in a "go vs. no go" decision on a potential location early in a project or location of the overall suite within a building. Most "typical" spaces will require at least some of the upgrades mentioned below; some projects require all of them.

Due to the extreme requirements created by the MRI suite for heating and cooling, an upgrade to the heating/ventilation/air conditioning (HVAC) system often is required. The possibility of an HVAC upgrade (additional equipment) requires early-stage consideration of routing from an outside area (often a roof) to the MRI suite itself.

Similarly, due to the extreme requirements an MRI suite creates for amount and nature of specialized power, an upgrade to the electrical system often is required. A possible electrical upgrade (additional electrical equipment) argues for the suite to be closer to the main source of power, usually the main electrical room, often found at the lowest level of the building.

Further upgrade requirements may include additional structural support for the magnet and the addition of a cryogen vent from the magnet to the outside, often requiring (again) consideration of routing from the MRI suite to the roof.

As is probably evident from the above, different upgrades argue for different locations within a building, so it is important to evaluate which upgrades are required and take these into account in deciding the

location of an MRI suite. In some cases, the feasibility (or lack thereof) of a required upgrade in a particular location may preclude locating the MRI suite in a certain building or location within that building.

Vibration and Sound

MRIs have special limitations regarding both vibration and sound, which often are grouped together conceptually (as they are here) due to the fact that one specialty consultant often deals with both. Just like manufacturer equipment specifications indicate requirements for infrastructure upgrades, those same specs indicate limitations on the vibration and sound, measured in decibels, which emanate from MRI equipment. The specialty consultant can offer advice on whether the floor requires vibration isolation and whether acoustical treatment should be added to the construction around the scan room to prevent the sound of the equipment from negatively impacting surrounding occupants.

Shielding

Also contained in the above-mentioned specs are the criteria driving the requirements for shielding of the MRI scan room. There are two types of shielding required for MRIs: radio frequency (RF) and magnetic. RF shielding blocks radio frequency electromagnetic radiation from entering the scan room, so this shielding essentially protects the equipment. It tends to be lighter, simpler and less expensive than the magnetic shielding. The magnetic shielding serves a dual purpose: protecting people and equipment outside of the scan room from the room's magnetic field and protecting the MRI imaging equipment itself from outside magnetic field influences, such as elevators and nearby cars, which can negatively impact the performance of the MRI equipment.

Planning

Once a location within a building is approved based on the above criteria, if there is flexibility in locating the MRI suite, it is ideally positioned toward the rear and less-trafficked portion of the radiology area, both to limit traffic into the suite and to reflect the fact that this modality generally has the longest and fewest scans of the range of radiology modalities typically found in a radiology department.

Considerations in planning the suite are: the scan room itself, the associated MRI equipment room, control room, dressing room, and waiting rooms (ideally a public waiting room as well as a gowned dressing room). A common mistake is to add an MRI scan room without taking into account the potentially increased requirements for dressing and waiting. The ACR-recommended four-zone plan is a good, safety-driven planning backbone for the suite, when supplemented by considerations of the other functional requirements of the MRI suite.

Important Limitations

There are two specific functional considerations for the MRI scan room itself. First, as a matter of safety, no ferrous material is allowed in the construction of the room. Second, lighting is limited to non-magnetic lighting.

Visual Appeal and Patient Comfort

It's hard to know whether this topic should be first or last in an article about MRI suite design considerations. We have taken the position in this article that imperatives related to safety and functionality must be addressed as a baseline requirement for the design of an MRI suite. Much of what has been discussed up until now is essentially back-of-house, not really visible to or experienced by the patient. But overlaid on a safe and functional backbone, it also is important to create a visually appealing and comfortable architectural interface for all of the above-described functionality.

In general, the design and operation of the MRI facility must go hand-in-hand with creating an appealing, comfortable environment. Neither the design nor the operation can achieve this goal without the support of the other.

From a design, the patient flow should be simple, logical and natural. Sufficient space should be allotted to support the architectural terms "circulation" and "repose," the spaces one moves through vs. the spaces one reposes in; think in terms of a flowing river as opposed to a still pool off to the side. Separation of inpatient and outpatient preparation and holding areas improve privacy and comfort for both populations.

Lighting is a key aesthetic factor in the design of an MRI suite, where over-lit is as bad as under-lit and glare is as bad as looking into a bare light bulb. Technical expertise must be brought to bear on the foot-candle analysis while creativity should drive the selection of fixtures, emphasizing indirect or at least shielded light wherever possible.

Acoustical considerations also are an important patient consideration. It's hard to relax and be comfortable when dealing head on with the volume and type of sound coming out of an MRI in operation. Thought should be given to reducing the level of that sound as much as possible throughout the suite and to dampening measures available inside of the scan room itself.

Finish and color selection are a matter of some personal preference, however try to choose finishes and colors that are rich, unusual and appealing but at the same time restful and not jarring to the patient. Soft pastels and muted colors work better in this regard than harsh colors or finishes. Similarly, natural materials tend to have a level of visual interest and depth which is both desirable and soothing.

Looking Forward

The MRI suite of the future will be more eco-friendly, likely to contain the rich and appealing colors found in nature along with natural materials, better ventilation, lighting in a more natural spectrum, more

real music (and less Muzak and equipment noise), appealing and natural scents (and less antiseptic smells), and as much patient control as possible of the personal environment (lighting, temperature, and sound). In short, the MRI suite will become an even greater and more essential part of the healing process.

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Importance of Ferromagnetic Detectors in MRI Safety

However well designed on MRI facility and its safety screening procedures may be, it is always a challenge for MRI professionals to be entirely confident about their ability to prevent ferromagnetic items from entering an MRI room and resulting in projectile incidents.

The primary challenge is that all of us lack the innate ability to visually distinguish between safe and unsafe items; e.g., a pair of safe non-ferrous scissors may be visibly identical to a risky ferrous item. Additionally, the information gained in traditional screening processes may be inaccurate, as patients are not always entirely reliable in reporting on items being carried or in conveying their medical histories.

Consequently, ferromagnetic detection systems (FMDs) have an important role to play in providing valuable objective data that assists technologists in their safety-decision making processes. However, it is very important that FMDs are not seen as a substitute for well-designed processes and training, but rather as providers of an added level of assurance when adopted as part of a well-founded safety culture.

Regarding the incorporation of FMDs, the American College of Radiology (ACR) recommends protection of the entrance to Zone 4, at the approach of the MRI doorway. Monitoring ferrous materials as they approach the doorway will provide added assurance against medium to large ferromagnetic items entering the MRI room and possibly causing a catastrophic incident. This installation should be designed to provide warning before the door, thus providing valuable reaction time before entry into Zone 4. The addition of ferromagnetic pre-screening capability in Zone 3 will enable the avoidance of image artifacts due to smaller ferrous items, such as hairpins, and can be an aid to efficiency by preventing delays and re-scans.

A well-designed FMD installation will enhance safety levels and reduce MRI staff stress levels by offering objective data for safety decision making.

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