CHAPTER 16

REMOTE AND HAZARDOUS LOCATIONS

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Checklist:

- Is the room size large enough to accommodate the fixed imaging equipment, the anesthesia equipment and monitors, the patient, and support staff?
- Is there adequate overall space to move anesthesia equipment if patient positioning changes or imaging equipment moves?
- Are suction, scavenging, medical gas lines, and electrical outlets located in more than one location if patient positioning will change?
- What are the energy hazards for this location? How will equipment, patients, and staff be protected from this hazard? How can observation of and access to the patient be optimized?
- Where will induction and recovery take place? Is transport necessary? What equipment is needed for transport? What is the most direct way to transport a patient to higher acuity areas?
- Are there adequate spaces for storage of disposable items?
- What is needed to summon help or access information?

Introduction

There is an increasing demand for non–operating room (OR) anesthesia in remote locations. These remote locations offer challenges to the provider beyond those found in the traditional OR suite. Data from the American Society of Anesthesiologists (ASA) Closed Claims database suggests that anesthesia at remote locations poses a significant risk for the patient. Many of these locations also expose the patient and provider to hazards. Procedural areas are often designed for their intended purpose (typically, imaging) without considering the needs of a patient receiving anesthetic care or the practitioners providing that care. In this chapter, we will discuss the considerations that should be made when designing a suite where anesthesia may be required.

Remote locations share several design challenges. These areas “belong” to other departments that are responsible for the costs of design, building, and maintenance. In considering both budget and who should be involved in the process, the concept of sedation or anesthesia needed for the clinical processes once the project is completed may not even be on the horizon. If it is considered, the knowledge of what is required for pre-procedure, intra-procedure, and post-procedure care may be limited.

It is critically important that anesthesia care providers be involved early in the design process, as retrofitting these areas can be prohibitively expensive or impossible, depending on fixed structures.

These locations are typically located far from the main perioperative areas because they need to be within the responsible department (e.g., radiology, radiation therapy, nuclear medicine, etc.) for support personnel and equipment and may need external facility access for ambulatory patients or other physical support. For example, many facilities share magnetic resonance imaging (MRI) or positron emission tomography units that exist on large trucks and are "attached" to the institution on a regular basis.

Anesthesia support facilities are not usually readily available away from the perioperative area. This means that replacement parts, anesthesia technicians, carts for rare events (e.g., malignant hyperthermia, difficult airway, etc.), laboratory data (e.g., arterial blood gases), recovery areas, and supportive colleagues are not close at hand. It is typically prohibitively expensive to keep these items at every non-OR location, so systems for their rapid transfer to the facility must be in place. In addition, anesthesia and OR information management systems may not be available or may not be usable (e.g., in high magnetic field areas), so anticipated patient data may not be easily found.

Some of the reasons why these locations exist so far from the perioperative area are that the equipment is very large, is fixed, and typically offers some type of energy hazard that is potentially dangerous to staff and patients and may greatly impact anesthesia equipment and monitors. Thought must be given to the overall size of the room, footprint of the imaging equipment, and footprint of the anesthesia equipment. There will likely be a need to move the anesthesia machines and monitors for different type of procedures, so locating suction, scavenging, and medical gas lines in more than one location should be considered. Transporting equipment (e.g., machines, carts, and monitors) from the ORs may decrease the life of this equipment. Keeping this equipment on site requires a separate storage area nearby if it is not used every day.

Every anesthetizing location has requirements which include:

- An area to conduct the pre-anesthetic assessment with consideration given to the patient's privacy and Health Insurance Portability and Accountability Act requirements
- An area in the procedure room for the anesthetic provider and the equipment necessary to conduct the anesthetic, located so that the provider has:
  - Access to the patient for both monitoring and intervention
  - The ability to communicate with and summon other qualified personnel should their assistance be necessary
  - A free approach to the patient so that others may assist in his/her care
  - The ability to evacuate the patient from the treatment area if necessary to avoid a hazard or provide more effective resuscitative efforts

- An area where post-anesthesia care can be provided or the ability to safely transport a patient to a post-anesthetic care unit
- Oxygen supply (and other medical gases as needed)
- Suction
- Scavenging outlet (waste anesthetic gas disposal)
- Adequate power outlets and lighting

It is recommended that persons designing facilities for anesthesia care away from the ORs review the following documents:
Statement on nonoperating room anesthetizing locations. 2003, 2008. Available at: http://www.asahq.org/publicationsAndServices/standards/14.pdf.

Practice advisory on anesthetic care for magnetic resonance imaging. 2008. Available at: http://www.asahq.org/publicationsAndServices/9.pdf.

ACR guidance document for safe MR practices. 2007. Available at: http://www.acr.org/SecondaryMainMenuCategories/quality_safety/MRSafety/safe_mr07.aspx.

Magnetic Resonance Imaging

MRI is a technique that utilizes fixed and time-varied magnetic fields along with radio-frequency pulses to provide computer-generated images.

The hazards in the MRI suite are associated with the magnetic field, high-frequency electromagnetic waves, and acoustic noise. Ferrous objects can become dangerous projectiles when acted upon by the magnetic fields. Patients and providers must be screened for the presence of implanted or imbedded ferrous materials and cardiac rhythm devices, which could be adversely affected by the magnetic fields and radiofrequency waves.

MRI suites have been categorized by the ASA and American College of Radiology (ACR) into three facility levels: 1) Level I facilities, where no anesthetic care is provided; 2) Level II facilities, where patients may require monitoring and life support; and Level III facilities, where operative procedures are performed. In this chapter, we will discuss the MRI suites associated with Level II facilities.

The ASA and ACR have also agreed on the delineation of zones to describe the physical plan of the MRI suite. This categorization is important in that it defines the effect of the magnetic field on each geographic area and, therefore, describes the potential hazard to patients and staff in that area. It is important to remember throughout the design process that the magnet is always "on," and exerting a magnetic field of (typically) 1.5 to 3 Tesla (the earth's magnetic field is less than 1 Gauss; 1000 Gauss = 1 Tesla).

Zone 1
Zone 1 is the main entry to the facility. It is generally outside of the MRI suite and freely accessible to the public.

Zone II

Zone II is generally the "meet and greet" area. It should include an area where anesthesia personnel and support personnel may be screened, with provisions for securing any personal items that are incompatible with an MRI environment. In Zone II, it is useful to have a room away from patient viewing where induction of anesthesia and/or recovery can safely take place using standard (ferromagnetic) monitors and equipment. An area for storage and deployment of resuscitative equipment will also be needed in this zone. This equipment should include a defibrillator, airway equipment, both wall and backup oxygen supplies, suction, and a code cart with appropriate resuscitative drugs. This zone should also be equipped to serve as a recovery area where postanesthesia care may be provided when necessary.

While it may be possible to perform an anesthetic induction with the associated airway management utilizing MRI-safe/conditional instrumentation in Zone IV, many practitioners find it more practical to perform this in Zone II and then (after shedding all MRI-unsafe objects) safely move the patient to Zones III and IV.

Zone III
Zone III is the restricted access area just outside the scanner magnet room. All MRI-unsafe objects should be eliminated prior to entry into Zone III. This zone should provide the anesthesiologist with the best possible view (beyond Zone IV), preferably a direct line of sight, of the patient during the scanning procedure. A video camera/monitor system may be necessary to optimize visual monitoring of the patient. Zone III should have slave displays of patient monitors that are housed in Zone IV. If possible, these displays should have remote control capabilities. An anesthesia machine or monitor kept within Zone III may have its breathing circuits or cables/tubing passed through wave guides between Zones III and IV. There must also be a readily available means of communication, providing the anesthesiologist with the ability to rapidly summon emergency assistance. Access to hospital information systems should also be available to the anesthesiologist.

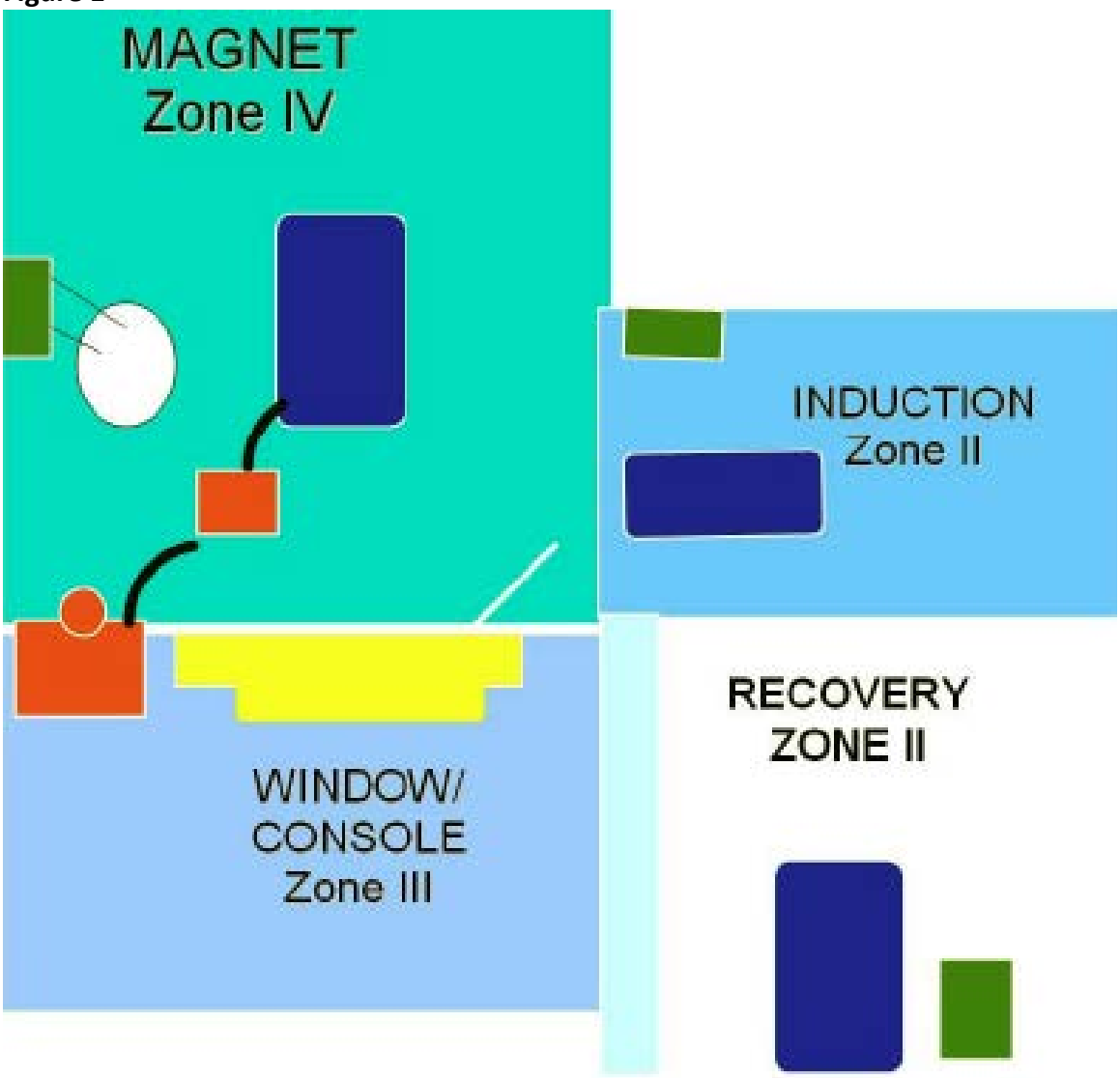
Zone IV
Zone IV is the MRI scanner magnet room itself. Admission to this zone must be limited to screened individuals and MRI-safe/conditional objects. Any leads, tubing, or circuits leading from Zone IV to Zone III should be passed through a wave guide to prevent radiofrequency interference within the scanner. The room should be designed so that an anesthesiologist in Zone III can have an unobstructed and, if possible, direct line of sight of the patient. The room must contain what has been outlined above as necessary to conduct a safe anesthetic. It is imperative that MRI-safe/conditional airway equipment and suction be immediately available in Zone IV at all times, and a space should be provided for its storage.

The design should provide for rapid patient egress in the case of an emergency. Management of a cardiac arrest requires patient movement to Zone II or III or an area equipped for this purpose. There is significant danger to the patient and medical staff if more than minimal patient interventions (e.g., suctioning or simple airway maneuvers) are performed in Zone IV due to inevitable non-MRI compatible equipment migration into this zone during an emergency. Provisions should be made for the use of an MRI-conditional anesthesia machine and installed oxygen supply and waste gas disposal. MRI-conditional monitors and infusion pumps are also available with slave devices that can be placed in Zone III.

Placement of these conditional items requires that the biomedical engineers have located Gauss lines within Zone IV. These lines indicate the magnitude of the magnetic field in different parts of the room relative to the magnet bore. Identifying Gauss lines allows safe placement of anesthetic machines and monitors, which contain some ferromagnetic material. Locating Gauss lines early in the design process will determine not only where movable equipment is placed relative to the patient, but also where to locate fixed wall medical gases and evacuation lines. Extra-long circuits are sometimes necessary to keep the anesthesia machine at the appropriate distance from the magnet bore.

Controversy exists within the anesthesia community regarding the best place to observe the patient during administration of anesthesia for MRI. Depending on the placement of the magnet, it is sometimes easier to actually visualize the patient within the bore from Zone III. If monitors and anesthesia machines are appropriately located, it is often possible to meticulously observe and monitor the patient without being in the magnet room, which minimizes the caregivers' exposure to high-decibel noise. In other design configurations (particularly locations that are retrofitted for acute care), it may not be possible to observe well without being in Zone IV with the patient, in which case hearing protection is required. With older magnets with which shielding is less robust, it may be necessary to locate all conditional equipment (including the anesthesia machine, monitors, and pumps) in Zone III, as no area of Zone IV has a low enough magnetic field to allow their use (Gauss line is actually in Zone III). In this case, all lines and tubing are passed through wave guides to reach the patient, as previously discussed.

Figure 1

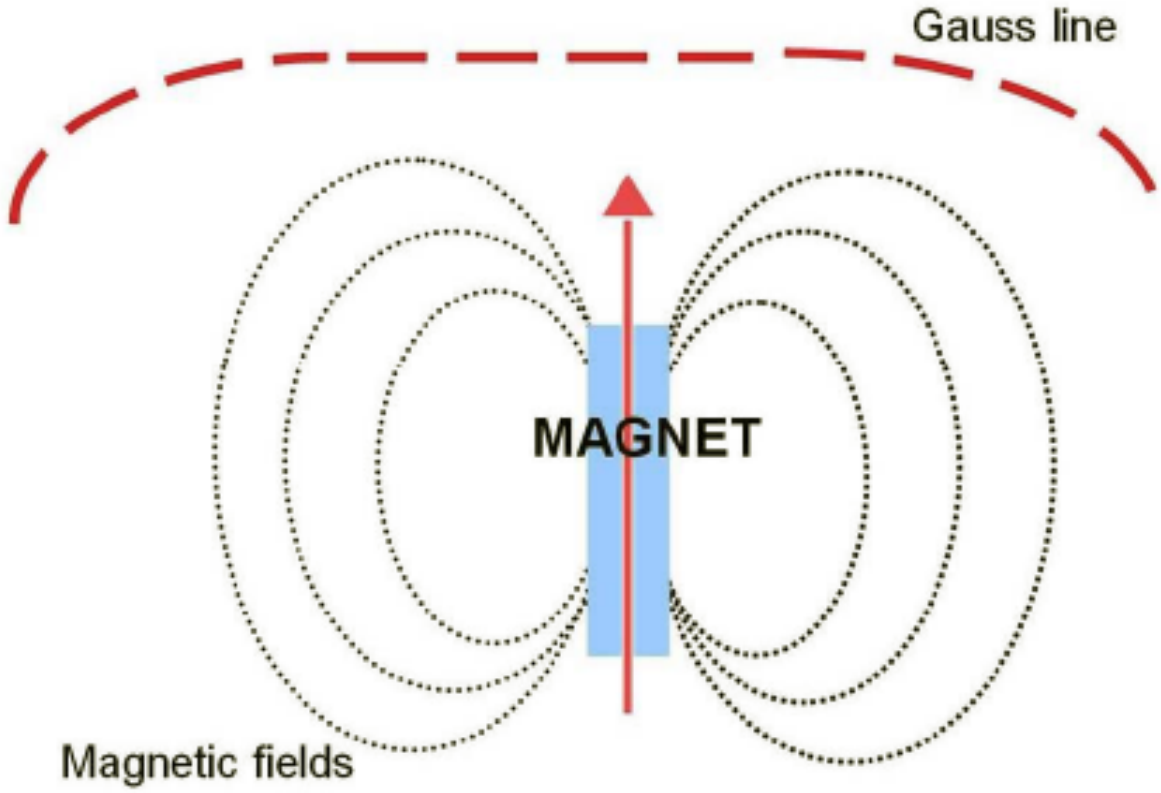


Green = wall gases, evacuation; white = anesthesia machine; orange = monitors and infusion pumps with slave.

A typical design for an MRI suite is illustrated above. Note the availability of wall gases and evacuation in each patient care location, the ability to have patient line of sight from the console window, as well as the ability to observe monitors and anesthesia machine information from the window. There is also space for the anesthesia caregiver within the magnet suite, if necessary, with views of the monitor and anesthesia machine.

Biomedical engineers should determine where the Gauss line is located in Zone IV in order to ensure safe placement of conditional equipment. For well-shielded magnets, the gauss line may drop to almost zero at the end of the patient table, but be very high at a 45° angle.

Figure 2



Radiology

Unfortunately, anesthesia involvement in the planning of radiology facilities is often an afterthought. By that time, radiology equipment is fixed and unmovable. Ideally, anesthesia considerations should be examined in the initial design phase. Besides designating and equipping areas for pre-anesthesia and post-anesthesia care, the greatest issue is competition for space within the radiology examination room. In cardiac catheterization, interventional radiology, fluoroscopy, and neuroradiology suites, the anesthesia machine and radiology equipment often compete for the same space.

The rooms should be designed so that the anesthesia equipment can be easily and safely moved and accessed while still connected to the patient to permit movement of overhead imaging equipment and the necessary radiological examination. Additionally, electrical cords and gas lines need to be placed to allow access but not act as a potential safety hazard to the staff as they move around the room. Depending on the nature of the study, the examination table is often moved during the radiological procedure. Connection to the anesthesia equipment needs to be guaranteed as the table moves. Many radiological studies do not require anesthesia assistance. During the design process, a determination where anesthesia equipment is to be stored when not needed is necessary.

It is important to locate sufficient electrical supply as well as wall medical gases and evacuation at every location in the suite where the anesthesia machine might be placed. Because different procedures require the patient, imaging equipment, and radiology staff to move, it is necessary to consider several room locations for anesthetic care. Sharing electrical resources may compromise anesthesia machines.

Radiation Therapy

Radiation therapy units are often located far from the main perioperative complex both for the convenience of ambulatory patients, who often come for daily treatments for several weeks, and because of the innate hazards of high-dose radiation. Because of the distance from the main perioperative areas, clear plans for induction and recovery of patients onsite are necessary.

Because of the intensity of the radiation, the radiation therapy suite needs to be designed to allow monitoring of an anesthetized patient from the device control room. In addition to the patient camera that is a part of the standard design of radiation rooms, the anesthesia care giver must be able to see the patient monitor from outside of the room. Placement of gas, vacuum, and electrical lines in the treatment room should correspond to where the anesthesia equipment is needed. Most radiation procedures are very short (lasting only seconds to minutes), and most of the patients requiring anesthetics for treatment are children. Further, these procedures are not in themselves painful. Although resuscitative equipment must always be available, it is not usually necessary to have consistent availability of anesthetic machines and extensive patient monitoring, as some type of rapid-acting intravenous anesthetic is usually sufficient.