Introducing Anesthesia to your MRI Environment
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A brief introduction . . .

Magnetic Resonance Imaging (MRI) is arguably the most versatile diagnostic tool in modern medicine. These powerful magnetic scanners attract an increasing diversity and number of patients from healthy outpatients, to the sickest patients in the intensive care unit. Completing a scan on a healthy outpatient may require only verbal reassurance to ensure the immobility required to obtain quality images. Many patients, however, require varying degrees of sedation and even general anesthesia to benefit from the diagnostic power of MRI. Although many anesthesia providers would prefer to never leave the operating room to provide anesthesia for patients during MRI, our services are needed for an increasing number of patients. In addition, a well run anesthesia service can improve the efficiency of the scanning process.

To care for patients safely in the MRI environment, one must understand the implications of the strong magnetic field. Magnetic fields are always present in the scanner room whether the patient is being scanned or not. The strength of these magnetic fields can vary, but all are quite powerful. Both providers and patients must remove all ferrous (iron-containing) objects before entering the scanner room or these objects become projectiles that can damage equipment or cause injury. Internal metallic objects may preclude some patients or care providers from entering the MRI room. Metallic objects that do not contain iron are safe in the MRI environment, such as aluminum compressed gas cylinders. Unless the metallic object is clearly marked as MRI compatible, it should not be taken into the scanner room. Screening for metal objects should be a routine activity prior to entering the scanning room.

The same monitoring and equipment standards that are used in the operating room should be used when providing anesthesia in MRI. MRI compatible equipment is readily available to facilitate safe care, but hospitals and radiology groups may be reluctant to invest in the technology, especially if the expected patient numbers requiring anesthesia are limited. Indeed, MRI compatible devices are more expensive than their non-MRI compatible counterparts, so the reluctance is understandable. Nevertheless, successful and safe anesthesia services require proper equipment and it is prudent to commit to providing anesthesia for patients undergoing MRI unless the equipment is available.

MRI COMPATIBLE: WHAT YOU NEED TO KNOW

MRI compatibility requires that the magnetic field not affect the device and that the device not interfere with the imaging process. Any device that is located in the scanner room is typically designed with a minimum amount of ferrous material. By minimizing the iron content, devices can be safely brought into the scanner room. The safe proximity to the magnet can vary from device to device and few can be located directly adjacent to the scanner. The strength of the magnetic field diminishes as the distance from the magnet bore increases. The strength of the field is described by gauss lines that define the strength of the field at different distances from the magnet.

These gauss lines are not visible, but the Radiology department will know the map of gauss lines at different locations in the scanner room. MRI compatible devices are tested and rated for compatibility at maximum field strength, and the device may not be brought closer to the magnet than the rated gauss line.

Fortunately, the electronic components in modern devices function well in the MRI environment despite the magnetic field, but all have the potential to interfere with the imaging process. MRI depends upon detecting small radio frequency signals that are altered as they pass through the patient in the presence of a strong magnetic field. Electronic devices in the scanner room have the potential to emit their own radio frequency signals that degrade the images that can be obtained. As a result, MRI compatible devices require extensive shielding and testing in the MRI environment. When selecting MRI compatible devices, it is important to work with a manufacturer that has the requisite expertise to design and test for MRI compatibility.

ESSENTIALS TO PATIENT SAFETY: TWO KEY TOPICS

PATIENT MONITORING

When providing anesthesia care in the MRI environment, the same requirements for safe monitoring that are used in the operating room must be satisfied. All of the required basic parameters – arterial blood pressure, electrocardiography, pulse oximetry, capnography, and temperature are available using MRI compatible technology. The best of these devices have a monitoring station which is located in the scanner room connected to the patient, but communicates wirelessly with a central display in the control room. These central displays not only allow for the patient to be monitored from outside of the scanner room, but can also be connected to an electronic recordkeeping system.

Wireless devices do not require the installation costs of running wires between the scanner room and the control room, but are more expensive than their wired counterparts. One should insist that MRI compatible monitoring devices are available sufficient to meet monitoring standards before agreeing to provide anesthesia care in the MRI environment.

INFUSION PUMPS

Infusion pumps are also essential to safe anesthesia care for MRI. The only
stimulation to the patient during MRI is the intermittent noise from the scanner, thus intravenous sedatives can be quite effective. Since MRI scans tend to require relatively long periods of time, infusions are more convenient than bolus techniques and a consistent level of sedation can be provided throughout the scan. MRI compatible infusion pumps that can be placed in the scanner room are available, convenient, and expensive, but not essential to providing continuous infusions during MRI.

Some scanner facilities have a specially constructed port between the control room and the scanner. Standard infusion pumps can be used with long lengths of tubing that travel from the pump, through the port, and to the patient’s intravenous line. The decision to use an MRI compatible pump, or a standard pump, will depend upon the budget and the availability of an access port between the control room and scanner rooms.

**MRI ANESTHESIA MACHINES: A QUICK OVERVIEW**

When caring for patients that require anesthesia and a controlled airway, an MRI compatible anesthesia machine becomes an essential tool.

**MODES OF VENTILATION**

Both inhalation and intravenous anesthesia can be provided with mechanical ventilation. MRI compatible machines that provide both controlled and supported modes of ventilation afford the most flexibility in patient care.

**MONITORING PARAMETERS**

Monitoring parameters measured by the anesthesia machine, such as gas concentrations, airway pressures, and tidal volume, are typically not available in the control room. The anesthesia provider should position the machine so that the displayed parameters are visible through the control room window. A full vaporizer and low fresh gas flows will help to prevent light anesthesia and awareness, especially if an anesthetic agent analyzer is not available.

**LOGISTICS: WHAT NOT TO OVERLOOK**

**NUMBER OF PATIENTS**

It is difficult to have a successful program of anesthesia care for MRI unless the number of patients requiring the service is significant. The costs of acquiring equipment and constructing the facility to support anesthesia services are too great to support casual use.

**SCANNER ROOM REQUIREMENTS**

Scanner rooms require gas supplies of oxygen and air at a minimum, patient suction, and anesthetic gas scavenging in addition to the connections between the scanner room and control room for patient monitors and infusion pumps. If the facility is not designed from the outset to support anesthesia care, the costs of “doing it right” can be prohibitive.

The MRI suite must accommodate initiating anesthesia and establishing airway access, or the patients must be transported from another location in the facility after airway control is completed. MRI compatible airway devices (laryngoscopes) are available and required if the patient is to be induced in the scanner room. MRI facilities that care for a large number of patients requiring anesthesia benefit from an induction and recovery area adjacent to the MRI scanners. That type of arrangement allows for patients to be prepared and recovered in close proximity to the anesthesia team and a minimum of delay between scans.

**TEAMWORK**

Establishing teamwork between the radiology and anesthesia care providers can be an unexpected challenge in the MRI environment. Due to the cost of the MRI scanners, the Radiology department is highly motivated to minimize the downtime between scans. Furthermore, patient throughput is typically controlled by MRI technicians who are not trained to understand the challenges of anesthesia care. It is not uncommon for the technicians to view the anesthesia team as an obstacle to the progression of the day. These impressions can be turned into a positive relationship by establishing communication and teamwork. Working with the head technician, or other people responsible for scheduling the scanners, can help create an understanding of the needs of each team. More importantly, it will prevent delays in getting patients into the scanner.

**NURSING ASSISTANCE**

In addition to the radiology technicians, nursing staff can be very important to a successful program of anesthesia for MRI. This is especially true if the anesthesia is provided by a single professional and not an anesthesia care team. That individual will be working in an environment remote from backup resources. Nurses can be trained to assist the anesthesia provider and will contribute to both the safety and the efficiency of the anesthesia services for MRI.

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**About the Author**

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FABIUS® MRI TECHNICAL DATA

BASE UNIT
Trolley Version (Cart) with COSY
Fabius MRI Trolley (with COSY)

POWER AND BATTERY BACKUP
Power Input
Operation time with fully charged batteries
Total Fresh gas flow indicators
O₂ flush
Vaporizer

VENTILATOR OPERATING SPECIFICATIONS
Ventilator E-vent®
Operating modes
CONTROL INPUT RANGES
Breathing Frequency (rate)
Positive End Expiratory Pressure (PEEP)
Inspiration/expiration ratio (Ti:Tn)
Pressure limiting (Pmax)
Tidal Volume (Vt)
Inspiration pause (Ti:Ti)
SIMV Inspiratory time
Inspiration pressure (Pinsp)
Pressure Support Level (PPS)
Min. frequency for apnoe-ventilation (Freq. Min.)
Trigger level
Integrated Safety Functions

VENTILATOR MONITORING
Monitoring
Expiratory Minute Volume range
Control Screen

BREATHING SYSTEM AND GAS SUPPLY
Volume of entire compact breathing system
Volume of CO₂ absorber
Gas Supply
Cylinder Yokes

OTHER
Writing surfaces
Additional accessories

Dimensions (W × H × D): approximately 39 × 55 × 35.5 in. (99 × 140 × 90 cm)
Weight and load without supplementary cylinders and vaporizers: 365 lbs. (165.8 kg)

100 to 240 VAC, 50 / 60 Hz, 70 VA, including additional power outlets
> 45 min

Power Input
Operation time with fully charged batteries
Total Fresh gas flow indicators
O₂ flush
Vaporizer

VENTILATOR OPERATING SPECIFICATIONS
Electronically controlled, electrically driven
Volume Controlled Ventilation, Pressure Controlled Ventilation, Pressure Support, SIMV/PS, Manual Ventilation, Spontaneous Breathing

CONTROL INPUT RANGES
Breathing Frequency (rate)
Positive End Expiratory Pressure (PEEP)
Inspiration/expiration ratio (Ti:Tn)
Pressure limiting (Pmax)
Tidal Volume (Vt)
Inspiration pause (Ti:Ti)
SIMV Inspiratory time
Inspiration pressure (Pinsp)
Pressure Support Level (PPS)
Min. frequency for apnoe-ventilation (Freq. Min.)
Trigger level
Integrated Safety Functions

VENTILATOR MONITORING
Continuous monitoring of inspiratory O₂ concentration, breathing frequency, tidal volume (expiratory), minute volume (expiratory), peak airway pressure, PEEP, and selection of mean or plateau pressure. In addition, all fresh gas flow information is displayed as virtual flow tubes.

BREATHING SYSTEM AND GAS SUPPLY
Volume of entire compact breathing system
Volume of CO₂ absorber
Gas Supply
Cylinder Yokes

OTHER
Pull-out tray (standard)
Secretion suction, anesthetic gas scavenging system