I Tuesday

MRI – medical implants

An additional step in the preoperative and preprocedural evaluation of a patient undergoing an MRI is the determination of any medical implants that the patient might have. An array of medical implants is possible. Examples of medical implants include: aneurysm clips, heart valves, pacemakers, defibrillators, spinal cord stimulators, stents, coils, prosthetic joints, filters, ESSURE device, deep brain stimulator (DBS). Implants can induce currents and heat depending on characteristics of the implant. The stronger magnetic field associated with MRI machines can influence movement of certain implants. Ferromagnetic materials are susceptible to movement within magnetic fields. Non-ferromagnetic materials, such as titanium, nitinol, and stainless steel, are unable to be manipulated by magnetic fields. In addition to potential movement, implants can be damaged and image artifacts can be observed. With the array of medical implants available, the implant manufacturer provides safety profiles for individual implants.

MRI Monitoring hazards.

Patients cannot be seen because they are generally enveloped by the MRI machine (although remote visualization should be employed, if available). EKG is confounded by **artifactual T and ST wave changes** (from aortic blood flow) as well as **artifacts from the magnetic field** . EKG **wires must *not* be coiled. Traditional pulse oximeters cannot be used** (due to the **“antenna effect,”** which can cause burns. MRI compatible oximeters do not physically connect the patient to the monitoring equipment).

MRI Monitoring Hazards

Patient Visibility: difficult / impossible to visualize patients in MRI

EKG: **T and ST wave artifacts** , among others. **Keep wires uncoiled**

Pulse oximetry: “antenna effect” mandates use of MRI-safe oximeters

Noise: precludes reliable auscultation

Other Points: loud noises (>90 dB) mandate ear protection. Ferromagnetic devices (pacers, AICDs, vascular clips) may be dislodged or broken

Who does this really concern?

children, ranging from newborn to 15 year old.

Some adults with impaired mental status

Why is this needed? The very nature of MRI examination makes it a unique situation in regard to anesthesia : the whole body must be introduced inside the MRI bore and no medical staff can stay near the patient.

This makes it **difficult to assess** – from the distant control room – the well being of the anesthetized patient.

What are the risks to the pt in the MRI suite?

- arousal
- aspiration
- hypoxia
- allergic shock
- hemodynamic impairment

So how to monitor the pt in the MRI suite?

- staff can't stay in the room with the pt
- Distant monitoring is the only mean to make sure of the well being of the patient during anesthesia
- often anesthesia machines are bulky and difficult to move from room to room. There are multiple setups of monitoring devices for the pt from room to room (i.e., induction room, transportation, MRI suite).

Physiologic parameters will have to be measured:

- ECG waveform (ECG) and heart rate (HR)
- Blood pressure (BP) with non invasive automatic cuff
- Plethysmographic waveform and SpO2 measure
- Temperature (T°) in case of a long procedure
- Inspired O2 (mandatory)
- Inspired and expired volatile anesthetic agents (mandatory if used)
- CO2 waveform and Expired tidal CO2 (PetCO2) (mandatory if tracheal intubation)
- Tidal volume (Vt) and respiratory rate (mandatory if tracheal intubation)

MRI – Contraindications

Absolute Contraindications to MRI include:

- Pulmonary artery monitoring catheters and temporary transvenous pacing leads
- Intra-aortic balloon pumps
- Left and right ventricular assist devices
- Epicardial leads, retained transvenous leads, fractured leads
- Ferromagnetic vascular clips
- Metallic foreign body (i.e. shrapnel, metal splinters, welding splinters, bullets, grenade fragments)
- Spinal cord neurostimulators
- Claustrophobia
- Body piercings
- Vascular access port
- Implants (i.e. insulin pump, prostheses)

Relative contraindications, (those that depend on the center/experience/location of the MRI sequences obtained/exact type of device/Tesla of the MRI):

- Cochlear implants
- Intrauterine contraceptive devices
- Implanted pacemakers and ICDs are considered a strong relative contraindication
- Intracranial endovascular clips must have the neurosurgeon's approval first
- Endovascular stent grafts depending on the material
- Tattoo/ permanent make up
- Renal insufficiency, if expecting to give contrast
- Tissue expander (i.e. breast)
- Cardiac valves
- Joint replacement
- IVC filters (early within 6 weeks of implantation)

II. Thursday

MRI – Resuscitation

- Zone I: This region includes all areas that are freely accessible to the general public.

- Zone II: This area is the interface between the publicly accessible uncontrolled zone I and the strictly controlled zone III
- Zone III: Only screened MRI patients and personnel have control to this restrictive zone. In this zone, there are potentially hazardous energies (related to the MR imaging process) present.
- Zone IV: The zone always located within Zone III. The zone houses the MRI scanner. In this zone, MRI patients under constant, direct supervision of trained MR personnel.

Patient care can be provided in all zones; however, the strong magnetic field in zone IV restricts resuscitation efforts as certain medical devices (i.e. defibrillators) cannot be used safely in Zone IV. The ASA updated their Practice Advisory on Anesthetic Care for Magnetic Resonance Imaging in 2014. As noted in the advisory:

When a patient has a medical emergency (e.g., cardiopulmonary arrest) in the MRI scanner, the following should occur:

1. Immediately remove the patient from zone IV while initiating CPR, if indicated
2. Call for help
3. Transport the patient to a previously designated safe area for resuscitation that is not in zone IV. This location should be as close to zone IV as possible so as not to delay resuscitation efforts and should contain the following resuscitation equipment: a defibrillator, vital signs monitors, and a code cart that includes resuscitation drugs, airway equipment, oxygen, and suction.

MRI- thermal burns

It is generally understood that direct electromagnetic induction in looped cables associated with the patient are responsible for the excessive heating, and it is on this theory that present guidelines are based.

MR systems require the use of RF pulses to create the MR signal. This RF energy is transmitted readily through free space from the transmit RF coil to the patient. When conducting materials are placed within the RF field, the result is a concentration of electrical currents sufficient to cause excessive heating and tissue damage. The nature of high frequency electromagnetic fields is such that the energy can be transmitted across open space and through insulators; therefore, only devices with carefully designed current paths can be made safe for use during MR procedures.

Updated definition 2020:

MRI requires radiofrequency pulses to create the MR signal, and therefore the desired image. If there are conductive materials placed near the RF field, that material can

concentrate the electrical currents from the radiofrequency pulses to generate enough heat to cause severe burns.3 This most commonly happens when conductive surfaces are looped or coiled, and electrical currents cycle in a continuous path. Insulating conductive surfaces via padding, or displacing from skin may not be enough to prevent thermal burns, so it is best practice to avoid burns by ensuring no ferrous material enters the MRI suite. 4

III. Friday

ASA guidelines: sedation

Except as noted, guidelines apply to both moderate and deep sedation.

1. Preprocedure evaluation Relevant history (major organ systems, sedation–anesthesia history, medications, allergies, last oral intake). Focused physical examination (to include heart, lungs, airway. Laboratory testing guided by underlying conditions and possible effect on patient management. Findings confirmed immediately before sedation.

2. Patient counseling Risks, benefits, limitations, and alternatives

3. Preprocedure fasting Elective procedures—sufficient time for gastric emptying. Urgent or emergent situations—potential for pulmonary aspiration considered in determining target level of sedation, delay of procedure, protection of trachea by intubation.

4. Monitoring Data to be recorded at appropriate intervals before, during, and after procedure. Pulse oximetry. Response to verbal commands when practical. Pulmonary ventilation (observation,auscultation, exhaled carbon dioxide monitoring considered when patients separated from caregiver. Blood pressure and heart rate at 5-min intervals unless contraindicated. Electrocardiograph for patients with significant cardiovascular disease.

For deep sedation: Response to verbal commands or more profound stimuli unless contraindicated. Exhaled CO2 monitoring considered for all patients. Electrocardiograph for all patients.

5. Personnel Designated individual, other than the practitioner performing the procedure, present to monitor the patient throughout the procedure. This individual may assist with minor interruptible tasks once patient is stable.

For deep sedation: The monitoring individual may not assist with other tasks.

6. Training Pharmacology of sedative and analgesic agents. Pharmacology of available antagonists Basic life support skills—present. Advanced life support skills—within 5 min.

For deep sedation: Advanced life support skills in the procedure room.

7. Emergency Equipment Suction, appropriately sized airway equipment, means of positive-pressure ventilation. Intravenous equipment, pharmacologic antagonists, and basic resuscitative medications. Defibrillator immediately available for patients with cardiovascular disease.

For deep sedation: Defibrillator immediately available for all patients

8. Supplemental Oxygen Oxygen delivery equipment available Oxygen administered if hypoxemia occurs

For deep sedation: Oxygen administered to all patients unless contraindicated

9. Choice of Agents Sedatives to decrease anxiety, promote somnolence. Analgesics to relieve pain.

10. Dose Titration Medications given incrementally with sufficient time between doses to assess effects Appropriate dose reduction if both sedatives and analgesics used. Repeat doses of oral medications not recommended.

11. Use of anesthetic induction agents (methohexital, propofol) Regardless of route of administration and intended level of sedation, patients should receive care consistent with deep sedation, including ability to rescue from unintended general anesthesia.

12. Intravenous Access Sedatives administered intravenously—maintain intravenous access. Sedatives administered by other routes—case-by-case decision. Individual with intravenous skills immediately available

13. Reversal Agents Naloxone and flumazenil available whenever opioids or benzodiazepines administered.

14. Recovery Observation until patients no longer at risk for cardiorespiratory depression. Appropriate discharge criteria to minimize risk of respiratory or cardiovascular depression after discharge.

15. Special Situations Severe underlying medical problems—consult with appropriate specialist if possible. Risk of severe cardiovascular or respiratory compromise or need for complete unresponsiveness to obtain adequate operating conditions—consult anesthesiologist

Moderate sedation: ASA guidelines

Basic, Generic Clinical Sciences

The ASA has produced guidelines that define levels of sedation.

- **Minimal Sedation** (Anxiolysis) is a drug-induced state during which patients respond normally to verbal commands. Example: Small amount of fentanyl or midazolam
- **Moderate Sedation/Analgesia** ("Conscious Sedation") is a drug-induced depression of consciousness during which patients respond purposefully to verbal commands, either alone or accompanied by light tactile stimulation. Example: More midazolam or fentanyl
- **Deep Sedation/Analgesia** is a drug-induced depression of consciousness during which patients cannot be easily aroused but respond purposefully following repeated or painful stimulation. The ability to independently maintain ventilatory function may be impaired.

Of note, airway intervention is, by definition, NOT required in a patient receiving moderate sedation.

Levels of Sedation: Definitions

Basic, Clinical Sciences: Anesthesia Procedures, Methods, and Techniques

According to the ASA Continuum of Depth of Sedation, the levels of sedation/analgesia are separated into 4 categories based on responsiveness, airway patency, adequacy of spontaneous ventilation, and cardiovascular function.

Minimal sedation/anxiolysis is a drug-induced state during which patients respond normally to verbal commands with intact airway reflexes and unaffected ventilatory and cardiovascular functions.

Moderate sedation/analgesia or "conscious sedation" is a drug-induced depression of consciousness during which patients respond purposefully to verbal commands +/- light tactile stimulation. Importantly, airway patency remains intact, and spontaneous ventilation is adequate. Cardiovascular function is usually maintained.

Deep sedation/analgesia is a drug-induced depression of consciousness during which patients cannot be easily aroused but respond purposefully to repeated or painful stimulation. Of note, reflex withdrawal from a painful stimulus is NOT considered a purposeful response. Intervention *may* be necessary to maintain airway patency, and

spontaneous ventilation *may* be inadequate. Cardiovascular function is usually maintained.

General anesthesia is a drug-induced loss of consciousness during which patients are not arousable even to painful stimulation. Intervention is *often* required to maintain airway patency, and spontaneous ventilation is *frequently* inadequate. Cardiovascular function may be impaired.