ABMRS Magnetic Resonance Safety Tech (MRST) Syllabus

1. **Static magnetic field (B_0, Static Magnetic Spatial Field Gradient (SFG))**
    a. Static magnet field physics
        i. Quantities and units (e.g., Tesla, Gauss)
        ii. Field lines/spatial field gradients
        iii. Magnetic properties of matter (e.g., diamagnetic, paramagnetic, ferromagnetic)
    b. Biologic effects
        i. Magnetophosphenes
        ii. EKG changes induced by blood flowing in a magnetic field
        iii. Vertigo, dizziness/nystagmus, nausea with motion in the static field
        iv. Teratogenesis/carcinogenesis and/or other long term exposure effects
        v. Pregnancy-related considerations
    c. Mechanical forces
        i. Translational forces (Missile effect)
            1. Static magnetic spatial field gradient exposure (aka SFG, dB_0/dx)
            2. Static field exposure (B_0)
            3. Spatial and force-related effect of magnetic shielding
            4. Force product (i.e., the product of the SFG and the B_0 at the location of the exposed object/material in question) 3D location of maximal translational force
        ii. Rotational forces (torque)
            1. 3D location of maximal rotational force (i.e., location of maximum B_0)
            2. Field orientation (horizontal, vertical, transverse)
        iii. Faraday's law of Induction, Lenz Law, Lorentz forces
                a. Dependence primarily upon:
                    i. B_0/static spatial field
                    ii. Orientation of electrical conductor relative to the lines of magnetic force
                    iii. Rate of motion of electrical conductor relative to B_0
                    iv. Dimensions and direction of motion of the moving electrically conductive material

ABMRS Magnetic Resonance Safety Tech (MRST) Syllabus

2. **Heating – only an issue for patients in the MR scanner itself and only during active MR imaging**
    - **a.** Diffuse heating => patient warming
        - **i.** Room temperatures/humidity levels should be kept to reflect manufacturer's recommendations
        - **ii.** Bore fan on MR scanner should be "on"
        - **iii.** Gown patients (fewer layers)
    - **b.** Focal heating => burns
        - **i.** Recognize the difference between focal and diffuse heating complaints and that each of them needs to be managed differently
        - **ii.** Must be able to differentiate between transmit, receive, and transmit/receive RF coils
        - **iii.** Should have general knowledge of volume that will undergo RF irradiation for the study to be performed
        - **iv.** Potential mechanisms of MR-related RF burns
            1. Proximity burns/patient tissue too close to/contiguous with the bore wall during MR scanning
                a. Larger patients are especially prone to proximity burns
                b. Proper use of *manufacturer provided* padding
            2. Prevent large caliber skin to skin loops of the patient's tissues from being even partially exposed to transmitted RF energies
                a. Proper use of appropriate padding/insulation
            3. Proper non-looped positioning of wires, leads, cables partially or completely external to the patient inside the MR scanner bore
                a. Proper use of appropriate padding/insulation
        - v. Anything external to the patient that is or may be electrically conductive (e.g., tattoos, wires, leads, non-removable jewelry/piercings, skin staples, electrically conductive clothing, foil-backed medication patches, springs in pillows, etc.) and even only partially within the volume that is to be exposed to transmitted RF energies must be prospectively brought to the attention of the scanning MR technologist

ABMRS Magnetic Resonance Safety Tech (MRST) Syllabus

3. **Hearing protection**
    - **a.** Sounds/noises made by the MR scanning during imaging can exceed 130 dB and can cause temporary or permanent hearing loss
    - **b.** We must reduce the sound pressure reaching anyone in Zone IV during active MR imaging to <99dB (on the A scale).
        - **i.** Recommend in ear as well as over the ear double protection
        - **ii.** Applies to patients being studied as well as anyone remaining in the MR magnet room/Zone IV during MR imaging (family members, healthcare personnel, etc.)

4. **Peripheral nerve stimulation**
    - **a.** Subtle, but may be felt by patient during active MR imaging
    - **b.** May feel like skin twitching, ants crawling on skin
    - **c.** Increased incidence if patient's arms or legs are crossed (large caliber electrically conductive loops of patient tissue)
    - **d.** NOT HARMFUL – very low likelihood of being uncomfortable
    - **e.** If PNS-like symptoms are reported by the patient, this should be non-emergently reported to the MR scanning technologist.

5. **Cryogen safety considerations**
    - **a.** Quench ventilation pathway considerations
    - **b.** Risks if quench ventilation pathway fails
        - i. Asphyxia
        - ii. Hypothermia/frostbite
        - iii. Ruptured eardrum
        - iv. "Pressure locking" doors/access pathways
    - **c.** Must know how to read/determine MR system cryogen levels (as applicable)
    - **d.** Must be familiar with the sounds expected to be produced by a normally functioning cryogen refrigerant system
    - **e.** MUST know when/how to perform a quench if required (based on site standard operating procedures/policies)

ABMRS Magnetic Resonance Safety Tech (MRST) Syllabus

6. **Gadolinium based contrast agents (GBCA) (if/as applicable; varies by state/site)**
    - **a.** Short term adverse effects
        - i. Non-allergic type: Nausea, emesis, headache, local injection site adverse reactions
            1. Proper management of local infiltration issues
        - ii. Allergic type: Hives, sneezing, swelling
        - iii. Anaphylaxis/anaphylactoid reactions
        - iv. Increased risk factors
            1. Previous adverse reaction to GBCA administration
            2. Asthma
            3. Multiple allergic histories
    - **b.** Pregnancy and intravenous GBCA administration considerations
        - i. Must verify administration, agent selection, and dosing for all known pregnant patients regardless of trimester
    - **c.** Long term adverse effects
        - i. Nephrogenic Systemic Fibrosis (NSF)
            1. Risk factors
                a. Renal disease
                - i. Increasing risk with increasing severity of renal disease
                - ii. Must verify administration, agent selection, and dosing for all patient with identified acute renal failure or stage IV (moderate; eGFR <30) or greater chronic renal disease

7. **MR scanner operation/maintenance**
    - **a.** Coordination with remote MR scanner operations
    - **b.** Turning on/off the MR scanner(s) if/as needed
    - **c.** Assisting in QA imaging/procedures/site certification activities
    - **d.** Assisting with routine preventive maintenance scheduling
    - **e.** Monitoring /ensuring zone IV/magnet room temperatures/humidity
    - **f.** Testing and maintenance of remote MR scanning hardware, audio/video connections, software updates, etc.
        - **i.** Awareness of site policies regarding function/communication loss
    - **g.** Managing/ensuring adequate cryogen levels, cryogenic refrigerant recovery systems if/as applicable

ABMRS Magnetic Resonance Safety Tech (MRST) Syllabus

8. **Primary management oversight over MR site access restriction**
    - **a.** Site access restriction
        - i. Detailed understanding of MR 4-Zone design
            1. Understanding device/implant/product testing/labeling for MRI
                a. MR Safe
                b. MR Conditional
                c. MR Unsafe
                d. On label versus off label
        - ii. Clearance and oversight of devices/objects into MR Zones III and/or IV
            1. Ensuring proper affixed labeling of devices entering Zone IV
        - iii. Clearance and oversight of non-MR personnel (e.g., security, housekeeping/maintenance) into MR scanning Zones III and/or IV (when no patient is in Zone IV) for NON-patient-related activities
            1. This includes review, assessment, and providing or denying clearance to non-MR personnel with passive implants
                a. On label only
                b. This includes access to Cryogen Venting Zone (e.g., on roof)
        - iv. The MRST is NOT authorized to clear non-MR personnel with active implants
        - v. The MRST is NOT authorized to clear non-MR personnel with off label passive implants/devices
        - vi. The MRST is NOT authorized on their own to clear ANYONE into any Zones III or IV for ANY routine medical/patient care related issues. Non-emergent medical care clearances can only be provided by the (remote or on-site) scanning MR technologist for whom the MRST serves as an assistant for all routine patient-related decisions/activities.

ABMRS Magnetic Resonance Safety Tech (MRST) Syllabus

9. **Primary management oversight over all on-site emergencies and adverse events**
    - **a.** Proper code management
        - i. Calling the code
        - ii. Prospectively defined location in which to execute the code
        - iii. Events/steps to execute by local site standard operating procedure
    - **b.** Proper management of all patient adverse medical events
    - **c.** Management of all emergency response personnel/first responders
        - i. Police
        - ii. Fire
        - iii. Security
        - iv. Code response teams
    - **d.** Quench considerations
        - i. When to quench and when not to quench
        - ii. How to quench
        - iii. What to expect in a quench (intentional, spontaneous)
        - iv. Site management in a failed quench
    - **e.** GBCA-related adverse reactions
        - i. Basic Life Support (BLS) (MANDATORY)
        - ii. Recognition/differentiation between minor and major adverse reactions
        - iii. Events/steps to execute by local site standard operating procedure
    - **f.** Power failure, environmental catastrophes, etc.
    - **g.** Communications loss with remote MR scanning personnel

ABMRS Magnetic Resonance Safety Tech (MRST) Syllabus

10. MRST role as assistant to (remote or on-site) scanning MR technologist

- **a.** Pre-MRI patient management
  - **i.** Coordination of all on site communication/integration with remote MR scanning technologist for routine MR scanning
    1. MRST is the "boots on the ground" (eyes, ears, hands, feet) of the remote MR scanning MR technologist
    2. **Must** report/communicate:
       a. Obesity/large patient habitus
       b. Unconscious/non-communicative patients
       c. Patients from whom a reliable history could not be/was not obtained
       d. Tattoos
       e. Onplants/implants
       f. Skin piercings and other non-removable jewelry/items
       g. Hair implants/extensions/wigs/products that are not removed/removable
       h. Removable/non-removable objects (e.g., braces, plates, jewelry)
       i. Voiced claustrophobia and/or anxiety
       j. Reporting any pre-medication the patient may have taken specifically for the pending MR examination
       k. Other stated patient concerns
       l. Febrile patient
       m. Positive/questionable patient pregnancy status (any trimester)
       n. Known patient adverse events (allergic or non-allergic) to prior GBCA administration and/or asthma and/or history of multiple allergies
       o. Any symptoms the patient reports having prior to being cleared into Zones III and/or IV
       p. All requested accompanying healthcare non-MR personnel
       q. All requested accompanying non-healthcare non-MR personnel
    3. Appropriate special care/precautions for patients who have reported taking medications (e.g., unsteadiness/fall risk)
  - **ii.** MR Magnet Room/Zone IV preparation

ABMRS Magnetic Resonance Safety Tech (MRST) Syllabus

b. Executing orders of (remote or on site) scanning MR technologist regarding oversight, screening, and on-site management (coordination, screening, access control/management) of routine and non-routine MR imaging examinations

i. Screening/coordination with non-MR healthcare personnel, e.g.:

1. Patient transport
2. Patient sedation and/or anesthesia
3. Respiratory therapy
4. Nursing
5. Physicians

ii. Screening/management of non-MR non-healthcare personnel, e.g.:

1. Accompanying family members
2. Patient guardians
3. Certified assistance animals
4. Security/prison guards accompanying prisoner patients
5. Special consideration of prisoner patients
   a. House arrest bracelet
   b. Handcuffs/other restraining devices

iii. Patient being scanned

1. Greet, confirm positive patient ID
   a. Confirm the requested examination(s)
   b. Confirm laterality of the examination (if/as applicable)
2. Pre-MRI screening
   a. Proper usage/function of ferromagnetic detectors
3. Pre-MRI gowning
4. Pre-GBCA administration if/as applicable:
   i. Patient ID
   ii. Ensuring/starting IV if/as applicable/ordered
   iii. Diagnosis being evaluated
   iv. History of any prior GBCA administration allergy/adverse event
   v. Asthma history
   vi. Pregnancy status
   vii. Multiple allergy history
   viii. Renal disease history

ABMRS Magnetic Resonance Safety Tech (MRST) Syllabus

5. Pre-MRI safety time out/full stop/final check
    a. Re-confirm patient ID
    b. Confirm the requested examination(s)
    c. Confirm laterality of the examination (if/as applicable)
    d. Proper pre-MRI screening performed and reported to (remote or in person) scanning MR technologist
    e. Ensure a proper order was issued to clear the patient for entry into Zone IV has been issued by the (remote or in person) scanning MR technologist
    f. Ensure proper gowning ordered and executed for the examination to be performed
    g. Ensure all equipment and non-MR personnel that are about to be brought into Zone IV have been prospectively cleared for that MR study by the (remote or in person) scanning MR technologist
    h. Proper laterality/positioning/centering/padding/RF transmitting coil selection orders have been issued for the examination to be performed
6. Positioning/centering/padding patient in MR scanner (and coil placement if/as applicable) as ordered
    a. Confirming safe positioning of patient and all equipment/monitoring devices prior to starting the examination
7. Confirm adequate hearing protection fit/function
8. Confirm emergency alert (e.g., squeeze ball, “call button”) education and implementation
9. Maintaining continuous audiovisual contact with the patient throughout MR examination
10. Responding to patient calls/“call button” activation
11. GBCA administration if/as applicable/ordered, verify:
    a. Agent
    b. Dose
    c. Rate
    d. Route
12. Ensuring execution of post-MRI orders if/as applicable/ordered

iv. Zone IV breakdown/cleanup post termination of patient study