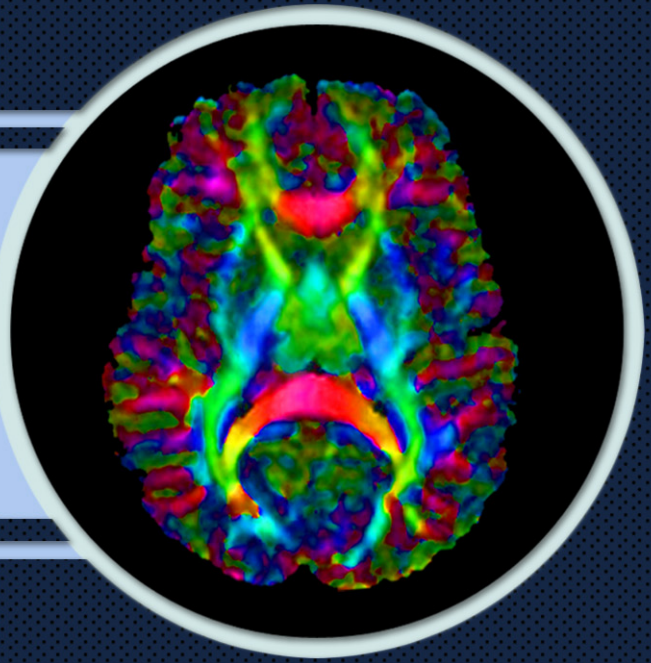
PDF

DIGITAL STUDY GUIDE

MRI "ALL-IN-ONE" Registry Review

2018



MRI ALL-IN-ONE EDUCATION

Josh J. Van Den Bossche

MRI
"ALL-IN-ONE"
Registry Review

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MRI ALL-IN-ONE
EDUCATION

MRI “All-In-One” Registry Review

www.MRIallinone.com

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Preface

MRI “All-In-One” Registry Review was written to guide today's students in preparation for the MRI registry examination. Having once been a student myself, I know how overwhelming the process of preparing for the registry examination can be. Many college educators, registry review seminar leaders, and online courses guide learners through multiple books, countless modules, as well as hours of PowerPoint lectures and notetaking in order to prepare students with relevant information needed to successfully pass the MRI registry examination. My goal was to help students relieve stress by creating a MRI registry review with tons of relevant information compiled "all-in-one" place. This MRI study guide follows an outline format similar to the content specifications outline that the ARRT registry examination follows, preventing learners from wasting valuable time having to search for relevant information throughout multiple resources, and allowing students to spend their time actually studying for the MRI registry exam. Within this detailed outline is a plethora of highly relevant information that has been acquired throughout my college education, extensive registry preparation, and while working within the field. Included in this study guide is a highly organized outline review, as well as multiple detailed charts (containing important numbers, regulations, equations, and parameters) located throughout the study guide and then again in a compilation at the end of the guide to make the absorption of information as easy as possible.

Josh J. Van Den Bossche

How To Use This E-book

DOWNLOAD ADOBE ACROBAT READER®

It is recommended to view this e-book with Adobe Acrobat Reader DC to take full advantage of the study guide's features. When using Adobe's PDF viewer, the reader gets a customized experience with the ability to highlight important text, to add one's own thoughts and notes by placing digital sticky-notes, and to draw doodles throughout the text to enhance the learning process. Also, Adobe's free PDF viewer may be needed to interact with the progress check boxes and online quiz score logs that are located at the end of each section of the study guide. Adobe Acrobat Reader DC is free to download on computer, mobile, or table by clicking the link below.

Step 1: Read a Section of this E-book - While reading, place your own highlights and sticky-notes throughout the text. When placing highlights in this study guide, take a different approach than you would when reading a textbook. Generally, highlights that readers place within lengthy textbooks are used in an attempt to mark important information so that the reader will have a manageable amount of text to study. Since this guide is already to reduced valuable information, the reader should aim to highlight hard-to-remember information that may require additional effort to retain.

Step 2: Complete Each Section's Online Practice Questions - After reading a section of this e-book and placing one's own highlights and sticky-notes, the reader should log in to the Members Area located at www.mriallinone.com to take the section's online practice quiz.

Step 3: Track Each Section's Progress - After reading a section of the study guide and completing the section's online practice questions, the reader should keep track of his/her progress using the progress tracker log located at the end of each section of this e-book. Simply click on a progress tracking check-box or enter an online quiz score to track one's progress while completing each section of the study guide.

Step 4: Go Back and Review Areas of Weakness - After reading a section of the guide, completing the section's online practice questions, and tracking one's progress within each section, the reader should navigate to the page at the end of the guide titled "Strengths and Weaknesses." This page is automatically populated as the reader completes each section's progress tracker to help identify sections that may require additional studying.

I. PATIENT CARE

1. LEGAL AND ETHICAL PRINCIPLES

A. Confirmation of Exam Requisition - The MRI technologist should always obtain informed consent and verify the following information before performing an MRI procedure.

- **Verification of Patient Identity** - The technologist needs to check and confirm at least two patient identifiers. Patient identifiers include the patient's wristband, name, date of birth, or medical record number.
- **Comparison of Request to Clinical Indications** - The reason for MR examination and the patient's diagnosis should be related to the anatomy that is being imaged. If the reason for examination or the diagnosis does not fit the type of exam ordered, the technologist should gain confirmation from the ordering physician. (ex. an MRI of the brain that is ordered for stomach pain)
- **Information Required to be on the Requisition** - The following 5 essential pieces of information must be included on the order requisition for an MRI examination.
    - Patient's name
    - The region to be examined
    - Corresponding diagnosis
    - Ordering physician
    - Date of examination

B. Legal Issues

- **Common Terminology**
    - **Assault** - Any act that causes another person to fear that he or she will be touched in an offensive, insulting, or physically injurious manner without consent.
    - **Battery** - The act of harmful, unwarranted, or unconsented contact with another person.
    - **Defamation** - An invasion of a person's reputation and good name. To avoid defamation, it is essential only to report the facts, and not to make assumptions.
        - **Libel** - The publication of defamatory matters by writing. Writing defamatory information inside the patient's chart could be used in court as Libel.
        - **Slander** - The publication of defamatory matters by any other means (ex. Speaking).
    - **Negligence** - Any form of unintentional misconduct, or when a standard of care is not followed.
    - **Tort** - A civil wrong that unfairly causes someone to suffer loss or harm.

- **False Imprisonment** - The illegal detention of an individual without consent.
- **Invasion of Privacy** - The intrusion into the personal life of another, without just cause.
- **Malpractice –** A rapidly growing type of medically specific negligence. Malpractice lawsuits can be prevented through competence, compliance, charting, communication, confidentiality, courtesy, and carefulness.
- **Beneficence** - The act of doing good. Commonly described by the phrase, "Do no harm."

- **Legal Doctrines**
  - **Respondeat Superior** - "Let the master answer." According to this concept, the employer is held liable for the employee's actions while working.
  - **Res Ipsa Loquitur** - "The thing speaks for itself." According to this concept, if an accident occurs and the accident generally only occurs when someone is negligent, then negligence likely took place (regardless if evidence is found that suggests negligence).

C. Patient's Rights - All patients have the "Right to Know" (informed consent), the "Right to Receive Healthcare," and most importantly, "The Right to Life."

- **Informed Consent** - A voluntary contract granting permission to perform a procedure and must be obtained prior to all medical procedures. For informed consent to take place, the patient must be given information that indicates the risks, benefits, alternatives of suggested treatments, and the risks of declining treatment. Informed consent helps maintain patient autonomy. Types of informed consent include written consent, oral consent, and implied consent.
  - **Written Consent** - A type of consent that is formally documented. Written consent is usually only required for invasive procedures and can only be obtained by the physician performing the procedure.
  - **Oral Consent** - A type of consent that is expressly spoken. Oral consent must be obtained to touch the patient during an MRI examination and to avoid a possible battery offense.
  - **Implied Consent** - A type of consent that is not directly granted by a person, but instead inferred from a person's actions and the facts and circumstances of a particular situation (or in some cases by an incoherent person's silence or inaction).
- **Confidentiality** - To keep secrets through multiple relationships whether it be employee-patient, employee-employer, or employee-employee. Examples of confidentiality within the healthcare environment include HIPPA, physical confidentiality, and Protective Health Information (PHI).
  - **Health Insurance Portability and Accountability Act (HIPPA)** - A legal act whose primary purposes is to streamline electronic healthcare information while ensuring the integrity, confidentiality, and availability of individually identifiable health information.

LEGAL AND ETHICAL PRINCIPLES

SECTION COMPLETE!

TIME TO TEST YOUR KNOWLEDGE!

Step 1

Quiz Yourself

Log in to access the Bonus Online Members Area by clicking the link below. Once logged in, navigate to the section of practice questions titled “Legal and Ethical Principles” to complete the provided practice questions.

CLICK HERE TO TAKE THE QUIZ

Step 2

Log Your Progress

This is a “Smart E-book” which means you can interact with it by typing your own information in the fields provided below, or by checking off the supplied progress boxes. Make sure to “Save” this study guide after updating the following fields so that you maintain any modifications applied.

LEGAL AND ETHICAL PRINCIPLES PROGRESS LOG			
I have read this section of the study guide and placed my own highlights and sticky-notes.	1st Read ☐	2nd Read ☐	3rd Read ☐
I have reviewed my highlights and sticky-notes, as well as all tables in this section.	1st Review ☐	2nd Review ☐	3rd Review ☐
Log your scores here after completing the online practice questions for this section.	1st Attempt	2nd Attempt	3rd Attempt

HOW WELL DO YOU KNOW THIS SECTION? You can come back and review the sections you are struggling with once you have completed all study materials.				
POOR	FAIR	AVERAGE	GOOD	* MASTERED *
☐	☐	☐	☐	☐

III. IMAGE PRODUCTION

PART 1: PHYSICAL PRINCIPLES OF IMAGE FORMATION

1. INSTRUMENTATION

The order of the instrumentation that composes the gantry from inside to outside is as follows: RF coils, Gradient coils, Shim coils, Magnet. Important instrumentation topics include the concepts of electromagnetism, the radiofrequency system, and the gradient system.

A. Electromagnetism - A force that deals with the physical relations between electricity and magnetism, and one of the four fundamental forces in nature (electromagnetism, gravity, weak forces, and strong forces).

- **Faraday's Law** – Otherwise known as the Law of Electromagnetic Induction, Faraday's law is the 1st law of electromagnetism. Faraday's law states that for electromagnetic induction to take place, a conductor, magnetic field, and motion (between the two) must be present. Components of Faraday's law are demonstrated when describing the magnetic characteristics and components of an MRI scanner. Faraday's law is also demonstrated during fast gradient applications where currents are induced in the body form the rapid application of alternating gradient magnetic fields. The factors that influence Faraday's law are listed below.
    - **Strength** - This refers to the strength of the magnetic field that interacts with a conductor. If magnetic field strength increases, then the current produced within the conductor increases, and vice versa.
    - **Speed of Motion** - This refers to the speed of a magnet in relation to a conductor. If magnet speed increases, then the current produced within the conductor increases.
    - **Angle of Interaction** - This refers to the angle of a magnet in relation to a conductor. When the interaction between a magnetic field and a conductor approaches 90^{o}, more current is produced within the conductor.
    - **Number of Coil Windings** – This refers to the number of windings within a conductive coil that is exposed to a magnetic field. As the number of windings in a conductive coil increase, more flux linkages occur between the conductive coil and the magnetic lines of flux

INSTRUMENTATION

SECTION COMPLETE!

TIME TO TEST YOUR KNOWLEDGE!

Step 1

Quiz Yourself

Login to access the Bonus Online Members Area by clicking the link below. Once logged in, navigate to the section of practice questions titled “Instrumentation” to complete the provided practice questions.

CLICK HERE TO TAKE THE QUIZ

Step 2

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INSTRUMENTATION PROGRESS LOG			
I have read this section of the study guide and placed my own highlights and sticky-notes.	1st Read ☐	2nd Read ☐	3rd Read ☐
I have reviewed my highlights and sticky-notes, as well as all tables in this section.	1st Review ☐	2nd Review ☐	3rd Review ☐
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☐	☐	☐	☐	☐

PART 2: SEQUENCE PARAMETERS AND OPTIONS

1. IMAGING PARAMETERS

A. Image Quality - The four pillars of MRI image quality are CNR, SNR, Spatial Resolution, and Acquisition Time.

- **Contrast to Noise Ratio (CNR)** - The difference in the SNR between two adjacent pixels. CNR determines the eye's ability to separate high signal areas from low signal areas. CNR has the greatest influence on image quality and is controlled by the same factors as SNR.
- **Signal to Noise Ratio (SNR)** - The ratio of signal amplitude to the average amplitude of the noise. Signal is predictable and is the induced voltage at the receiver coil. Noise is random and is dependent on the patient's build and the background electrical noise of the MRI imaging system. SNR is most greatly affected by the size of the FOV applied during imaging.
- **Spatial Resolution** - The ability of the imaging system to detect two points as separate and distinguishable. An image's spatial resolution is enhanced by employing square pixels instead of rectangular pixels. However, the only characteristic that directly affects the measurable spatial resolution is voxel volume.
    - **Voxel Volume** - The amount of tissue within a three-dimensional volume. Voxel volume is calculated using the FOV size, matrix size, and slice thickness. Voxel volume is the sole characteristic that determines spatial resolution.

VOXEL VOLUME CALCULATION
Equation: Pixel Phase Dimension x Pixel Frequency Dimension x Slice Thickness = Voxel Volume
Example: What is the voxel volume when using a 24cm FOV, a 256x128 matrix, and a 3mm slice thickness? (240mm/256) x (240mm/128) x 3 = 5.27mm^3

    - **Square Pixels** - A pixel shape that provides better spatial resolution than rectangular pixels. Obtaining square pixels is best when reformatting 2D/3D image acquisition. The technologist can maintain square pixels in two ways: by using a square FOV with a square matrix, or by using a rectangular FOV with a rectangular matrix.
- **Acquisition Time** - The amount of time it takes to fill k-space during data acquisition. Acquisition time has the greatest impact on the amount of patient movement that is detected during imaging. The only parameters that impact acquisition time are the TR, NSA, Phase Matrix, Number of Slices (only during 3D imaging), and Echo Train Length (ETL).

2D SCAN TIME CALCULATION
Conventional Sequences Equation: TR x NSA x Phase Encodings

Example: 500ms x 1 x 256 = 128sec = 2 min, 8 sec
Fast Sequences Equation: (TR x NSA x Phase Encodings) / ETL
Example: (500MS x 1 x 256) / 4 = 32,000 msec = 32 sec
3D SCAN TIME CALCULATION **Always assume test questions are asking about 2D image acquisition scan time unless a question specifically states that 3D image acquisition is employed. 3D scan time calculations include the slice number as an additional variable.**
Conventional Sequences Equation: TR x NSA x Phase Encodings x Slice #
Example: 500ms x 1 x 256 x 8 = 1,024 sec = 17 min, 4 sec

B. Image Contrast and Weighting

- **Factors Affecting Image Contrast**
  - **Intrinsic Parameters** - Parameters that are inherent to the body's tissues and cannot be changed (ex. T1 recovery, T2 decay, proton density, flow, apparent diffusion coefficient, perfusion, diffusion).
  - **Extrinsic Parameters** - Parameters that can be changed via the imaging system (ex. TR, TE, flip angle, TI, echo train length, b value, FOV, matrix).
- **Types of Image Contrast** - The appearance of MRI images relies on T1 contrast, T2 contrast, and proton density contrast.
  - **T1 Contrast** - The type of imaging contrast achieved when fat has high signal and appears bright, while water has low signal and appears dark.
  - **T2 Contrast** - The type of imaging contrast achieved when fat has low signal and appears dark, while water has high signal and appears bright.
  - **Proton Density Contrast** - The type of imaging contrast that appears as a difference in signal intensities between tissues with varying hydrogen proton concentrations.
- **Types of Image Weighting** - The amount of T1 or T2 contrast that has been allowed to influence an image will determine its weighting.
  - **T1 Weighted** - Images in which weighting mainly depends on the differences between the T1 relaxation times of fat and water. The objective when trying to achieve T1 weighting is to prevent recovery and prevent decay, which is why a short TR and short TE are generally applied. However, T1 image weighting is directly controlled by the TR selected during imaging.
  - **T2 Weighted** - Images in which weighting mainly depends on the differences between the T2 decay times of fat and water. The objective when trying to achieve T2 weighting is to allow recovery and allow decay, which is why a long TR and long TE are generally applied. However, T2 image weighting is directly controlled by the TE selected during imaging.
  - **Proton (spin) Density Weighted** - Images in which weighting mainly depends on the difference in the number of mobile hydrogen atoms within adjacent tissues. The objective

when trying to achieve PD weighting is to allow recovery and prevent decay, which is why a long TR and short TE are generally applied. However, PD weighting is directly controlled intrinsically by the number of mobile hydrogen atoms present in the tissue being imaged.

- **T2* Weighted** - Images in which weighting depends on the combination of T2 decay and magnetic field inhomogeneities. The objective when trying to achieve T2* weighting is to allow recovery and allow decay during a pulse sequence that contains magnetic field inhomogeneities, which is why a long TR and long TE are generally applied during a Gradient Echo pulse sequence. However, T2* weighting is directly controlled by the TE selected during imaging.

C. Parameters

- **TR** - The repetition time (TR) is the time between applied alpha pulses and is measured in milliseconds (ms). TR directly controls T1 image weighting.
- **TE** - The echo time (TE) is the time between the alpha pulse and the peak of the echo and is measured in milliseconds (ms). TE directly controls T2 image weighting.
- **TI** - The time of inversion (TI) is a parameter used only in Inversion Recovery (IR) pulse sequences. This parameter is used to null the signal from specific tissues (fat or fluid) and is present between the 180^{o} inversion pulse and the 90^{o} alpha pulse. During T1 weighted IR pulse sequences, the applied TI value controls the amount of T1 contrast obtained during imaging (along with the selected TR). During T2 weighted IR pulse sequences, the applied TI value controls which tissue signals will become nulled during imaging.
- **Number of Signals Averaged (NSA)** - The number of times that data is collected per TR period. NSA has a square root relationship with SNR and a directly proportional relationship with scan time.
  - **Double NSA** - If the NSA is doubled, the scan time gets doubled, yet there is only a 41% increase in SNR. Doubling the NSA is useful when attempting to improve image quality with a moderate increase in signal, but the increase in scan time can also allow image quality to suffer in other areas (ex. motion artifact can increase).
  - **Quadruple NSA** - If the NSA is quadrupled, the scan time is quadrupled, and there is a 100% increase in signal (signal is doubled). Quadrupling the NSA is useful when attempting to improve image quality with a considerable increase in signal, but the drastic increase in scan time can also allow image quality to suffer in other areas (ex. motion artifact can increase).
- **Flip Angle (Ernst Angle)** - The angle of the NMV to the direction of the main magnetic field. Flip angle is controlled by the amplitude and duration of incoming RF pulses. Flip angles closer to 90^{o}, or the transverse plane, provide more signal than flip angles closer to the horizontal plane.
- **FOV** - The area of anatomy that is covered in an image. The FOV selected has a directly proportional

IMAGING PARAMETERS

SECTION COMPLETE!

TIME TO TEST YOUR KNOWLEDGE!

Step 1

Quiz Yourself

Login to access the Bonus Online Members Area by clicking the link below. Once logged in, navigate to the section of practice questions titled “Imaging Parameters” to complete the provided practice questions.

CLICK HERE TO TAKE THE QUIZ

Step 2

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IMAGING PARAMETERS PROGRESS LOG			
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HOW WELL DO YOU KNOW THIS SECTION? You can come back and review the sections you are struggling with once you have completed all study materials.				
POOR	FAIR	AVERAGE	GOOD	* MASTERED *
☐	☐	☐	☐	☐

REVIEW: Areas of Weakness

Use the following progress chart to identify any sections that may require further studying. The check-boxes on this chart sync with the progress charts provided at the end of each section in this study guide. Once you have completed a section of the guide and logged your competency on the bottom row of the section's progress chart, this chart will update automatically so that you can identify any weak areas once you have reached the end of the guide.

IDENTIFY STRENGTHS AND WEAKNESSES

PATIENT CARE

SECTION	POOR	FAIR	AVERAGE	GOOD	* MASTERED *
1. Legal and Ethical Principles	☐	☐	☐	☐	☐
2. Infection Control	☐	☐	☐	☐	☐
3. Interpersonal Communication	☐	☐	☐	☐	☐
4. Patient Assessment Monitoring and Management	☐	☐	☐	☐	☐
5. Pharmacology	☐	☐	☐	☐	☐

SAFETY

SECTION	POOR	FAIR	AVERAGE	GOOD	* MASTERED *
1. MRI Screening and Safety	☐	☐	☐	☐	☐

IMAGE PRODUCTION

Part 1: Physical Principles of Image Formation

SECTION	POOR	FAIR	AVERAGE	GOOD	* MASTERED *
1. Instrumentation	☐	☐	☐	☐	☐
2. Fundamentals	☐	☐	☐	☐	☐
3. Artifacts	☐	☐	☐	☐	☐

4. Quality Control	☐	☐	☐	☐	☐
Part 2: Sequence Parameters and Options					
SECTION	POOR	FAIR	AVERAGE	GOOD	* MASTERED *
1. Imaging Parameters	☐	☐	☐	☐	☐
2. Imaging Options	☐	☐	☐	☐	☐
Part 3: Data Acquisition and Processing					
SECTION	POOR	FAIR	AVERAGE	GOOD	* MASTERED *
1. Pulse Sequences	☐	☐	☐	☐	☐
2. Data Manipulation	☐	☐	☐	☐	☐
3. Special Procedures	☐	☐	☐	☐	☐
PROCEDURES					
1. Anatomy and Physiology	☐	☐	☐	☐	☐
2. Patient Set-Up	☐	☐	☐	☐	☐

MEMORIZE: Tables

Use this section of the study guide to quickly memorize the guide's tables, numbers, and equations prior to testing day. Numbers and equations tend to be forgotten easily as their retention tends to rely more on one's memory than comprehension. For this reason, all of the study guide's tables and numbers have been compiled in this section so they can be easily memorized prior to the reader's registry exam.

VITAL SIGNS	
Heart Rate / Pulse Measured by palpating the carotid, radial, temporal, femoral, or pedal artery.	Adults: 70-80 bpm Children: 90-100 bpm
Blood Pressure Measured with a sphygmometer.	Systolic: 110-140 mmHg Diastolic: 60-80 mmHg
Respiratory Rate Measured through auscultation (listening) or with a ventilator.	12-20 breaths/min
Temperature Measured with a thermometer in several locations	Oral: 98.6° F Axillary: 97.6° F Tympanic: 97.6° F Rectal: 99.6° F

CPR COMPRESSION TECHNIQUES	
Rate	80-100 compressions per minute
Depth	1.5-2 inches
Ratio	1 Rescuer: 30 compressions and 2 breaths 2 Rescuer: 30 compressions and 2

--- END OF SECTION ---