



MR Protocol Review Clinical Opportunities for Physicists

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AAPM Spring Clinical Meeting
New Orleans, LA
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No conflict of interest to declare

AAPM Newsletter March/April 2017

• Physics Summit on Imaging Physics – Dr. Thomadsen, AAPM President-Elect's Report

- "The future of imaging physics is very much more uncertain than the issues discussed at the summit"
- "Other than [QA] testing and review, further interactions between the medical physicist and the facility depends on the largess of its director since there is no identifiable revenue stream for imaging physics as there is for therapy"
- "This is a big loss for the facility, the patients, and the medical physicist"

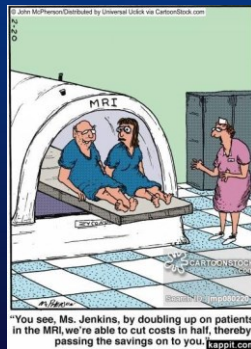


Technical to Clinical Transition - How?

• PROTOCOLS

"It is the scanner protocols NOT accreditation that determines individual patient care"

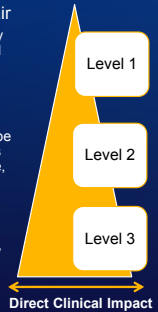
– Dr. William Pavlicek, Chair
Medical Physics, Radiology,
Mayo Arizona



Technical to Clinical Transition - How?

• Diagnostic Work and Workforce Study Subcommittee (DWWSS) – Dustin Gress, Chair

- **Level 1:** Well defined, mandated by either regulatory requirements or national accreditation programs and are required to be performed by or under the supervision of a medical physicist. Example, **annual physics QA**
- **Level 2:** Somewhat mature, but non-mandatory to be performed by a medical physicist. Medical physicists add value when performing these services. Example, designing a **fluoroscopy safety program per Report 168 NCRP**
- **Level 3:** Neither well defined nor mandated by authorities outside the healthcare institution. Broadly categorized as research or developmental services. Example, **dual-energy CT dose optimization**



Technical to Clinical – MR Safety

- MRI safety policy review
 - **Level 2** activity mainly carried out by physicians and MRI technologists in many settings
 - ACR Expert Panel on MR Safety publications, most recent 2013
- ACR MRI Accreditation Program 2015 requirement annual review of MR safety program an explicit (**Level 1**) medical physicist responsibility

Technical to Clinical – CT Protocol

- CT protocol review committee participation
 - Established at **Level 2** with the publication of AAPM MPPG #1a
 - Became **Level 1** service for all Joint Commission-accredited facilities effective July 1, 2015 with new accreditation requirements for diagnostic imaging
- MR can learn from CT protocol efforts!
"Imitation is the sincerest form of flattery"

MR Protocol – DWWSS Level of Service

- **Level 1: Required for accreditation under mandatory physicist supervision**
 - Parameter review for ACR physics phantom QC
 - Annual MR safety survey
 - Acoustic noise – GE Silent, Siemens Quite
- **Level 2: Structured, needed for accreditation or patient care, medical physicists involvement not required**
 - ACR parameter review for clinical MR protocols
 - Low-SAR protocol development- Pacemakers, Neurostimulators
- **Level 3: Neither well defined nor mandated, primarily research and clinical development activities**
 - Image acquisition optimization – fat sat, metal artifact reduction
 - New sequences, hardware, software
 - **Bonus material!**



MR Protocol Review

Level 1


- Required for accreditation under mandatory physicist supervision

Level 2

Level 3



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STEP 02

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STEP 03

Get Started

STEP 04

Prepare for the

01 | Program Requirements

The ACR's Magnetom Program evaluation staff utilizes quality, certified, and qualified personnel to ensure the Magnetom Program for the Medicine Program is best suited for your facility.

01 | Program Requirements

Before applying for accreditation, please review the document below for a program requirements:

- Prospective Magnetom Program Candidate
- Accredited Program Requirements Updated 6-23-16
- Additional Program Requirements for Adult/Physician Specialty
- Instructions for Submitting Applications Updated 11-16-16

02 | Frequently Asked Questions

• General Accreditation FAQ

• Magnetom Accreditation FAQ

03 | Register/Log In

Facilities applying for ACR accreditation (for first time) begin to register with the online accreditation system.

Entering users: If you already have an account, please log in to access your facility/profile. If the sign program has changed, please see the document below to enter the system.


- Access the online accreditation system
- Log in to access your account or create a new user
- Effective July 1, 2016, ACR will discontinue face-to-face interviews for all new users in order to meet interview requirements for transferring providers data. After this date, only the following users will be supported:
 - Single Physician Credential
 - Single Physician Firm
 - General Practice Physician (GP)
 - Charge user log in

MRI Equipment Evaluation Summary		MRI Safety Program Assessment Checklist	
Name	Report Date	Site	
System ID#	Survey Date		
System Manufacturer	Model		
Medical Physicist/Healthcare Provider			
Signature			
<p>Equipment Evaluation Tests</p> <p>1. Setup and Table Position Accuracy</p> <p>2. Center Frequency</p> <p>3. Transmitter Gain or Attenuation</p> <p>4. Geometric Accuracy Measurements (weekly)</p> <p>5. High-Contrast Spatial Resolution (weekly)</p> <p>6. Low-Contrast Detectability (weekly)</p> <p>7. Artifact Evaluation (weekly)</p> <p>8. Film Printer Quality Control (if applicable)</p> <p>9. Visual Checklist (weekly)</p> <p>10. Magnetic Field Homogeneity</p> <p>11. Method of Tuning</p> <p>11.1. Slice Position Accuracy</p> <p>11.2. Slice Thickness Accuracy</p> <p>13. Radiofrequency Coil Checks</p> <p>14. Presence of clinically used coil indicators? (Yes/no) <input type="checkbox"/></p> <p>15. a. SWS</p> <p>16. b. Volume Coil Control Image Uniformity (PD only)</p> <p>17. c. Percent Digital Clipping (PD only)</p> <p>18. Self-Cover Monitor Quality Control</p> <p>19. MRI Safety Program Assessment (weekly)</p> <p><i>* Tests not to be evaluated by scanning the ACRI Phantom</i></p>		<p>The site's written MRI safety policy addresses the following:</p> <p>1. Designated MRI medical director</p> <p>2. Site access restrictions (MRI zones)</p> <p>3. Documented MRI safety education/training for all personnel</p> <p>4. Patient and non-MRI personnel screening</p> <p>5. Pediatric patients</p> <p>6. Magnet safety</p> <p>7. Cryogen safety</p> <p>8. Acoustic noise</p> <p>9. Pregnant patients and staff</p> <p>10. Contrast agent safety</p> <p>11. Sedations</p> <p>11.1. Thermal Burns</p> <p>11.2. Emergency code procedures</p> <p>12. Device and device screening</p> <p>13. Deactivation of MRI safety/field conditional status</p> <p>17. Reporting of MRI safety incidents or adverse incidents</p> <p>18. Patient communication</p> <p>19. Infection control and medical waste</p>	
<p>Pass/Fail/NA</p>		<p>Yes/No/NA</p>	
<p>Overall Pass/Fail/NA</p>		<p>Overall Pass/Fail/NA</p>	
<p>ACRI criteria for compliance:</p> <p>1. Written policies are present and readily available to facility staff</p> <p>2. Written policies are reviewed and updated on a regular basis</p> <p>3. Facility has appropriate MRI safety warning signage and methods of controlled access</p>		<p>Yes/No/NA</p>	
<p>Medical Physicist's or MRI Scientist's Recommendations for Quality Improvement</p>		<p>Reviewed by:</p> <p>Qualified Medical Physicist/MRI Scientist</p> <p>Date</p>	

Phantom QA Acquisition Protocol

Pulse Sequence Acquisition Parameters

*In the box below each parameter:
Record actual values if they differ from the prescribed protocol parameters or
Place a check mark to indicate use of prescribed parameters
Fill in all parameters for "Your Site's Axial T1- and T2-weighted Brain Scan"*



	a	b	c	d	e	f	g	h	i	j	k	l
Study	Pulse Sequence	TR (ms)	TE (ms)	FOV (cm)	Number of Slices	Slice Thickness (mm)	Slice Gap (mm)	NEX	Matrix		Routine Receive Band-Width (kHz)	Scan Time (min:sec)
8.	ACR Sagittal locator	Spin Echo	200	20	25	1	20	N/A	1	256	256	0:56
								N/A				
9.	ACR Axial T1	Spin Echo	500	20	25	11	5	5	1	256	256	2:16
10.	ACR Axial T2 Double-echo	Spin Echo	2000	20/80	25	11	5	5	1	256	256	8:56
				/								
11.	Your Site's Axial T1 weighted Brain Scan					Freq: 11	5	5				
						Phase:						
12.	Your Site's Axial T2 weighted Brain Scan					Freq: 11	5	5				
						Phase:						

13. Scan Options Used on the ACR Spin-echo T1- and T2-weighted Axial Scans: _____

14. Scan Options Used on "Your Site's Axial T1- and T2-weighted Brain Scans": _____

15. Serial number of phantom used for testing: _____

	Other AEC	
	I INTC ACC	
	JAC MRI Accred	
	about	
	getting	
	how to become Accred	
	benefits	
	accreditation	
	program multifactor	
	helpful to	
	frequently asked questions	
	after you	
	SAC MRI Interviewing QMS Issues MR-033-20 MR-033-21	
MARCO CLINIC OF PHYSICIANS		

Part B:

Examinations and Procedures

Section 1B: Instrumentation and Equipment

STANDARD – Instrumentation

- 1.1B FDA approved MRI device(s) must be available.
- 1.1.B The MRI unit must be capable of performing multipleplanar images using T1, T2 and STIR sequences with the field of view large enough to consistently image all relevant anatomy in the region of interest.
- 1.2.B The equipment specifications and performance must meet all state, federal and local requirements.
(See Guidelines on Page 22 for further recommendations.)

STANDARD – Equipment Quality Control

- 1.2.B The **Equipment Quality Control (EQC)** documentation **must** consist of MRI system installation acceptance testing and acceptance testing following a major upgrade.
- 1.2.B The manufacturer's representative, service engineer, or the MRI site-appointed medical physicist, or qualified expert must perform the acceptance testing.
- 1.2.B The system parameters must be compared to the manufacturer's system specifications or industry standards and reviewed by **appropriate staff**. Acceptance testing must include (where applicable to the scanner):
 - 1.2.2.1B magnetic field homogeneity;
 - 1.2.2.2B gradient and RF calibration;

MR Protocol Review

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- Required for accreditation under mandatory physicist supervision

Level 2

- Structured, accreditation or pt care, medical physicists involvement not required

Level 3



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658 | RADIOLOGY

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660 | ACCREDITED FACILITY SEARCH

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Physicist QC Check - ACR Cervical Spine

Accession: **FAILED**

	Sagittal dark fluid	Sagittal bright fluid	Axial bright fluid
Slice thickness (≤ 3.0 mm)	Pass	Pass	Pass
Gap (≤ 1.0 mm)	Pass	Fail	Pass
In plane pixel(read) (≤ 1.0 mm)	Pass	Pass	Pass
In plane pixel(phase) (≤ 1.0 mm)	Pass	Pass	Fail
Pixel area (≤ 1.0 mm)	Fail	Pass	Pass



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ACR Cardiac Delayed Enhanced

Delayed Enhanced Cine with Black Blood ¹			
Required Sequences	Category A: Pulse Sequence and Image Contrast	Category B: Anatomic Coverage and Imaging Plane. Failure to meet these specifications will result in failure.	Category D: Spatial Resolution
BLACK BLOOD - Axial	<ul style="list-style-type: none"> Must be gated to the cardiac cycle Must have no significant arrhythmia during the left cardiac cycle Must be T1 or T2-weighted T2 or proton density-weighted (2.0-8.0mm TE) Must be in the axial plane Must have good myocardium discrimination (including good blood suppression) TE can be optimized for your system, but should be proton density T1-weighted (less than 100ms) <p>This sequence may be from a different patient than the other sequences. Note that single shot (e.g., "HASTE", "SSFSE" or "STSE") imaging technique is not acceptable.</p>	Must cover from aortic root to diaphragm (axial)	Slice thickness ≤ 3.0 mm Gap ≤ 4 mm In plane pixel (read) ≤ 1.0 mm In plane pixel (phase) ≤ 2.5 mm Pixel area ≤ 4.0 mm ²
SHORT AXIS CINE	<ul style="list-style-type: none"> Must be gated to the cardiac cycle Must have no significant arrhythmia during the left cardiac cycle Real time cine images are not acceptable Must show entire systolic cycle Must have good myocardium discrimination (including good blood suppression) Must image and systolic and end diastolic Steady State free precession technique is preferred, but fast gradient echo is allowed 	Must cover entire left ventricle from base to apex	Slice thickness ≤ 3.0 mm In plane pixel (read) ≤ 1.0 mm In plane pixel (phase) ≤ 2.5 mm Pixel area ≤ 4.0 mm ² Temporal resolution (SD msec) (without view sharing)
LONG AXIS CINE 2 Chamber	<ul style="list-style-type: none"> Must be gated to the cardiac cycle Must have no significant arrhythmia during the left cardiac cycle Real time cine images are not acceptable Must show entire systolic cycle Must have good myocardium discrimination (including good blood suppression) Must image and systolic and end diastolic Steady State free precession technique is preferred, but fast gradient echo is allowed 	Single slice oriented vertically through the middle portion of the left atrium and the middle portion of the left ventricle	Slice thickness ≤ 3.0 mm In plane pixel (read) ≤ 1.0 mm In plane pixel (phase) ≤ 2.5 mm Pixel area ≤ 4.0 mm ² Temporal resolution (SD msec) (without view sharing)
LONG AXIS CINE 4 Chamber	<ul style="list-style-type: none"> Must be gated to the cardiac cycle Must have no significant arrhythmia during the left cardiac cycle Real time cine images are not acceptable Must show entire systolic cycle Must have good myocardium discrimination (including good blood suppression) Must image and systolic and end diastolic Steady State free precession technique is preferred, but fast gradient echo is allowed 	Single slice oriented vertically through the middle portion of the left atrium and the middle portion of the left ventricle	Slice thickness ≤ 3.0 mm In plane pixel (read) ≤ 1.0 mm In plane pixel (phase) ≤ 2.5 mm Pixel area ≤ 4.0 mm ² Temporal resolution (SD msec) (without view sharing)
LONG AXIS CINE Aortic Outflow Tract	<ul style="list-style-type: none"> Must be gated to the cardiac cycle Must have no significant arrhythmia during the left cardiac cycle Real time cine images are not acceptable Must show entire systolic cycle Must have good myocardium discrimination (including good blood suppression) Must image and systolic and end diastolic Steady State free precession technique is preferred, but fast gradient echo is allowed 	Single slice oriented vertically through the middle portion of the left atrium and the middle portion of the left ventricle	Slice thickness ≤ 3.0 mm In plane pixel (read) ≤ 1.0 mm In plane pixel (phase) ≤ 2.5 mm Pixel area ≤ 4.0 mm ² Temporal resolution (SD msec) (without view sharing)
DELAYED GADOLINIUM ENHANCED	<ul style="list-style-type: none"> Must be gated to the cardiac cycle Must have no significant arrhythmia during the left cardiac cycle Real time cine images are not acceptable Must show entire systolic cycle Must have good myocardium discrimination (including good blood suppression) Must image and systolic and end diastolic Steady State free precession technique is preferred, but fast gradient echo is allowed 	Must cover entire left ventricle from base to apex in the short axis	Slice thickness ≤ 3.0 mm Gap ≤ 2.5 mm In plane pixel (read) ≤ 1.0 mm In plane pixel (phase) ≤ 2.5 mm Pixel area ≤ 4.0 mm ²



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ACR Cardiac Delayed Enhanced

CLINICAL TEST IMAGE DATABASE (DELAYED ENHANCED CINE WITH BLACK BLOOD)									
1. Scanner Serial Number:	40327								
2. Manufacturer:	Siemens								
3. Model Name:	MAGNETOM SPECTRA 3T								
4. Year manufactured:	2012								
Type of exam:	Cardiac Delayed Cine with Black Blood								
Date of exam:	06/10/2013								
Reason for exam:	PULMONARY, CARDIOVASCULAR, ACS								
Age of patient:	51								
Approximate weight of patient, if applicable (kg):	90.0								
Parameter	Short Axis Cine 2 Chamber	Long Axis Cine 2 Chamber	Long Axis Cine 4 Chamber	Long Axis Cine Aortic Outflow Tract	Delayed Gadolinium Enhanced	Black Blood Sequence			
Sequence name/type	SHORT AXIS (STACK T1T2)	2CH T1T2	4CH 5CH T1T2	AOL T1T2	T1 SAG DELAYS FL	DBL DB T1T2			
Sequence #	30	31	32	33	34	35			
Orientation	Coronal	Coronal	Coronal	Coronal	Coronal	Apex			
Slice thickness (mm)	5.0	5.0	5.0	5.0	5.0	5.0			
Gap (mm)	0.00	0.00	0.00	0.00	1.40	0.00			
FOV (mm)	270.0	312.0	297.0	312.0	360.0	270.0			
FOV (mm)	340.0	340.0	340.0	340.0	360.0	340.0			
TD (acquisition phase matrix)	128.0	128.0	127.0	128.0	128.0	128.0			
TD (acquisition frequency matrix)	224.0	224.0	224.0	224.0	224.0	224.0			
TD (reconstruction phase matrix)	176.0	208.0	196.0	208.0	224.0	208.0			
TD (reconstruction frequency matrix)	224.0	224.0	224.0	224.0	224.0	224.0			
TD (display phase matrix)	128.0	208.0	196.0	208.0	224.0	208.0			
TD (display frequency matrix)	224.0	224.0	224.0	224.0	224.0	224.0			
# Partitions	1,000	1,000	1,000	1,000	1,000	1,000			
TR (ms)	20,000	20,000	20,000	20,000	500,000	154,000			
TE (ms)	1.8	1.5	1.5	1.5	2.0	1.5			
Flip angle	77	90	90	90	20	90			
TD	0	0	0	0	0	0			
Temporal resolution (ms)	50	24	36	24	500	50			
# Views per Sequence	7	7	7	7	41	7			



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MR Protocol Review

Level 1

• Required for accreditation under mandatory physicist supervision

Level 2

• Structured, accreditation or pt care, medical physicists involvement not required

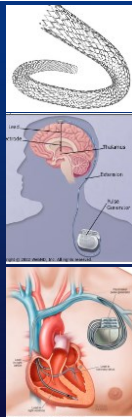
Level 3



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Low SAR Protocol Development

- Growing need for low SAR sequences
 - Patients with reduced thermoregulator capacity
 - Cardiac impairment; hypertension; diabetes; obesity; fever
 - Pregnancy (risk for fetal heating)
 - Unconscious, sedated, locally anesthetized
- Patients with implanted devices
 - Stents, retained leads, wires
 - Neurostimulators: DBS (0.1W/kg), VNS
 - Cardiac Devices: Pacemakers, ICDs, CRT-Ds



FDA MR-Conditional Approvals: 2015 vs 2016

2015

2016

Pacemakers

- Medtronic Revo
- Medtronic Adviva
- Biotronik Entovis
- Biotronik Eluna

Pacemakers

- Boston Scientific Accolade
- Boston Scientific Essentio
- Medtronic Micra Pacemaker

ICDs

- Medtronic Evera

ICDs

- Boston Scientific Emblem
- Biotronik Iperia 7 VR-T DX
- Biotronik Inventra VR-T DX
- Biotronik Iforia DR-T / VR-T DX
- Medtronic Visia AF

CRT-Ds

- Biotronik Iperia HF-T
- Biotronik Inventra HF-T
- Medtronic Ampla Quad
- Medtronic Compia Quad



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SUPERSAR TECHNOLOGIST Pacemaker/ICD SAR Monitoring Sheet			
Updated Form on: 4/20/2016			
Date:			
SupersAR Technologist:			
Scanning MR Technologist:			
PACEMAKER/ICD DETAILS			
Is this a Pacemaker or ICD?		Yes/No	
Is this an MR-Conditional device?		Yes/No	
Is Pacemaker set at MR Compatible Mode, eg. SureScan?		Yes/No	
If MR Conditional ICD, is ICD turned OFF?		Yes/No	
MR CONDITIONAL Pacemaker/ICD Info:		MR CONDITIONAL Lead Info:	
Manufacturer:		Manufacturer:	
Model/Serial:		Model/Serial:	
Implantation Date:		Implantation Date:	
MR Conditional:		MR Conditional:	
SCANNER AND PROTOCOL DETAILS			
MRI scanner:		MRI scanner:	
MRI region scanned:		MRI region scanned:	
Coil used:		Coil used:	
Pacemaker protocol used:		Pacemaker protocol used:	
(Only use Pacemaker Protocols; if no protocol present please contact for on-call physician before proceeding)		(Only use Pacemaker Protocols; if no protocol present please contact for on-call physician before proceeding)	
State performed on 1.5T scanner:		State performed on 1.5T scanner:	
SAR Reduction Strategies:		General Notes:	
STEP 1: Increase TR			
STEP 2: Decrease flip angle			
STEP 3: Decrease # of slices (for 2D scans)			
STEP 4: Reduce echo-train-length for FSE			
STEP 5: If the strategies don't work, contact on-call Physician			
If Physician Contacted:		Physician name:	
Physician section:		Physician name:	
Final physician approval:		Physician name:	
Name:		Date:	

SAR Reduction Strategies

- Set RF Type to "Low SAR", "Normal Mode"
- Decrease # of slices (for 2D scans)
- Decrease # of averages
- Eliminate SAT bands and Fat Sat
- Increase TR
- Decrease flip angle
- Reduce echo-train-length for FSE/TSE
 - Gradient echo scans provide less SAR than spin echo
 - Spin echo scans provide less SAR than fast (turbo) spin echo



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MR Protocol Review

Level 1

- Required for accreditation under mandatory physicist supervision

Level 2

- Structured, accreditation or pt care, medical physicists involvement not required

Level 3

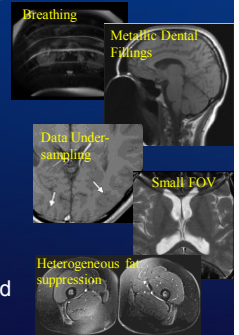
- Neither well defined nor mandated, primarily research and clinical development activities



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MRI Artifacts – Protocol Optimization

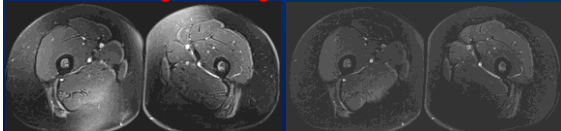
- Ghosting (Motion)
- Susceptibility (Metal)
- Gibbs Ringing (Truncation)
- Wrap-around (Aliasing)
- Inhomogeneous B_0 or B_1 field



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Inhomogeneous Field - Fat Suppression

Axial T2-weighted Thigh MRI



Chemically selective saturation (CHESS)

Spectral Attenuated Inversion Recovery (SPAIR)



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Fat Suppression Techniques

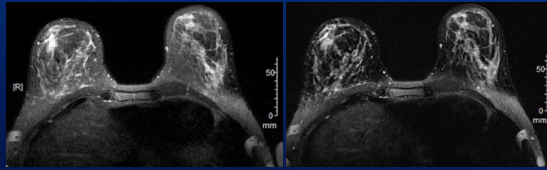
Name of Technique	Method	Time Penalty	SAR	Sens. To B_0	Sens. To B_1	Comments
CHESS/ Fat-Sat	Chemical Shift	Small	Med	High	High	Most popular & versatile technique; works best at high fields (1.5T-3.0T); cannot use at fields <0.3T; poor or incomplete suppression near metal
Dixon	Chemical Shift	Large	Low	Low	Low	2 pt. & 3+ pt. methods; generate 4 images in one acquisition (in-phase, out-of-phase, water only, and fat only); commercial implementations: GE (IDEAL, Flex), Siemens (Dixon), Philips (mDixon), Hitachi (FatSep), Toshiba (WFOP)
Water excitation	Chemical Shift	Small	Low	High	Low	Binomial pulses (1-1, 1-2-1, 1-3-3-1); most widely used in MSK; good method for midfield (0.3-1.0T); commercial implementations: GE (SSRF), Siemens (WE), Philips (ProSet), Toshiba (PASTA, WET)
STIR	T1	Large	High	Low	Low	Widely used; works at all field strengths; tolerant of B_0 and B_1 inhomogeneities; nonspecific suppression of all short T1 materials (fat, protein, blood); cannot use post-Gad; images are T2-weighted
SPIR	Hybrid	Med	Med	High	High	Combination of CHESS+STIR: spectrally selective RF pulse inverts fat only, signal generated after T1 delay. Images retain T1-weighting and can be used post Gad; cannot use at low fields (<0.3T) or poorly shimmed magnets; commercial implementations: GE (SPECIAL, SSRF), Philips (SPIR)
SPAIR	Hybrid	Large	High	High	Low	Same as SPIR but uses adiabatic inverting pulse that minimizes sensitivity to B_0 nonuniformity; useful in abdominal breath-hold studies

mri-q.com – Dr. Elster



Fat Suppression: CHESS vs STIR

T2-weighted Breast MRI



Chemically selective saturation (CHESS) fat suppression

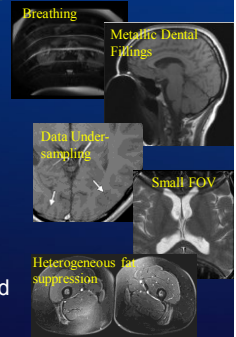
Short tau inversion recovery (STIR) fat suppression



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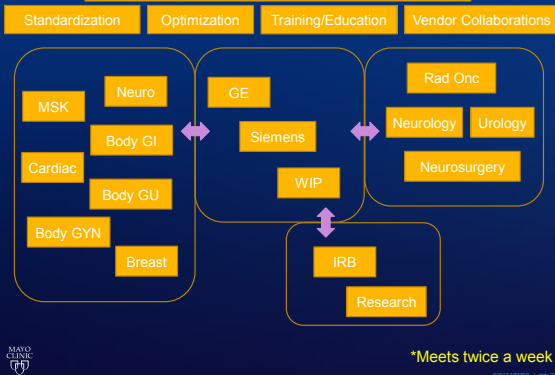
MRI Artifacts – Protocol Optimization

- Ghosting (Motion)
- Susceptibility (Metal)
- Gibbs Ringing (Truncation)
- Wrap-around (Aliasing)
- Inhomogeneous B_0 or B_1 field



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MR Protocol Committee



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MR Protocol Review

Level 1

- Required for accreditation under mandatory physicist supervision

Level 2

- Structured, needed for accreditation, medical physicists involvement not required

Level 3

- Neither well defined nor mandated, primarily research and clinical development activities

Level 3+ Bonus Material



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MR Practice Complexity – Mayo AZ

• 2012 – FIVE Scanners • 2017 – EIGHT Scanners

- All GE 1.5T
- All 16x
- FIVE GE scanners
 - FOUR 1.5T; ONE 3T
 - 16x (Long Bore)
 - 24x
 - 25x
- TWO Siemens Skyra
 - Both VE 11
- 2016 - GE 3.0 T PET/MR

Variability is the enemy of quality



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MR Protocol Inconsistency Issues

- MR practice quality issues
 - Protocol inconsistencies
 - Image quality (SE vs FSE)
 - Missing images (sequences per protocol)
 - Hanging protocol mismatch on PACS (sequence order)
- Workflow inefficiencies - Technologists
 - Identifying right protocol
 - Indication, coil, and specialty protocols
 - On-the-fly changes
- Workflow inefficiencies - Radiologists
 - Protocols hanging on PACS
 - Indication based protocoling
 - Interruptions with missed images
- Suboptimal patient care



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Dot Cockpit - Explorer

PROGRAM EDITOR

SOURCE Import Export

CLINICAL

CLINICAL + 10HEAD + 05RN 20CH + 010RTN 2

RTN

AAHSC QSC100010

SAG T1 FLAIR QSC10010

AX DIFF RESOLVE QSC10010

STROKE

STROKE yes

COR DIFF RESOLVE Q9A100010

AX T2 TSE IR QSC10010

AX T2SR SWI QSC10010

MPR Planning

CLINICAL

- DAILY ACR
- NEURO
- 10HEAD
- 05RN 20CH
 - 010RTN 20CH
 - 012FAST RTN 20CH
 - 020METS 20CH
 - 030ATV 20CH
 - 040MS 20CH
 - 050MAC 20CH
 - 060TLY 20CH
 - 070PT 20CH
 - 080POST FOSSA 20CH
 - 090TTR NERVE 20CH
 - 100MRA HEAD 110MRA AN
 - 120MRV HEAD 20CH
 - 130MRA NECK 20CH
 - 140TEMP ARTERY 20CH
 - 05RN TR COL
 - 05RN 64CH


MARIO CLINIC

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Protocol Standardization


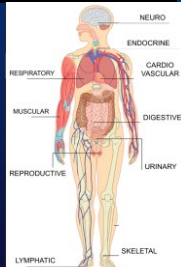

NEURO	MSK	BODY
92	64	126
100RNR 010RTN 20CH	20SHOULDER 010RTN	300LWR MRCP 010RTN
100ERN 010RTN 64CH	20SHOULDER 010RTN BODY18	300LWR MRCP 011MED BH
100ERN 012SF RTN 20CH	20SHOULDER 011METAL RTN	300LWR MRCP 012SHORT BH
100ERN 012SF RTN 64CH	20SHOULDER 012SF RTN	300LWR MRCP 013RTR
100ERN 013MOTN RTN 20CH	20SHOULDER 013MOTN RTN	300LWR MRCP 014LARGE FOV
100ERN 013MOTN RTN 64CH	20SHOULDER 020ARTH	300LWR MRCP AB 010RTN
100ERN 020METS 20CH	20ELBOW 010RTN KNEE COIL	300LWR MRCP AB 011MED BH
100ERN 020METS 64CH	20ELBOW 010RTN LG FLEX	300LWR MRCP AB 012SHORT BH
100ERN 030ART 20CH	20ELBOW 011METAL RTN KNEE COIL	300LWR MRCP AB 014LARGE FOV
100ERN 030ART 64CH	20ELBOW 011METAL RTN LG FLEX	301LWR 010EOSTV
100ERN 040MS 20CH	20ELBOW 020ARTH KNEE COIL	301LWR 020STRUCTURE
100ERN 040MS 64CH	20ELBOW SUPINE 010RTN LG FLEX	301LWR 030SPHINCTER OF OODI
100ERN 050M 20CH	20ELBOW SUPINE 011METAL RTN LG FLEX	301LWR 040SPUR
100ERN 050M FULL 64CH	20WRIST 010RTN	301LWR 060HEMORRHOIDOST
100ERN 050AC LTD 20CH	20WRIST 010RTN SM FLEX	302LWR MRCP LTD PEL 010RTN
100ERN 050AC LTD 64CH	20WRIST 011METAL RTN	302LWR MRCP LTD PEL AB 010RTN
100ERN 060LT 20CH	20WRIST 011METAL RTN SM FLEX	310ENTERO AB 010RTN
100ERN 060LT 64CH	20WRIST 020ARTH	311APPENDIX 010RTN
100ERN 070DYN PIT 20CH	20WRIST SUPINE 010RTN	312LMPHANGIOGRAM 010RTN
100ERN 070DYN PIT 64CH	20WRIST SUPINE 011METAL SM FLEX	320KIDNEY 010RTN
100ERN 070M 20CH	20WRIST SUPINE 011METAL RTN	321ADRENAL 010RTN
100ERN 070P 64CH	20WRIST SUPINE 011METAL RTN FLEX	322UROGRAM 010RTN
100ERN 080POST FOSSA 20CH	210HJEMURIS 010RTN	322UROGRAM 020NO GAD



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Unique MR Protocols

- 60 MRI Scanners
 - Multiple vendors (GE and Siemens)
 - Multiple hardware versions (1.5T, 3.0T)
 - Multiple software versions (VE11, 16x, 23x, 25x)
 - 7 unique combination at Mayo Arizona of vendor+hardware+software
- Radiology practice
 - Neuro, Body, MSK, Cardiac, Breast
 - 320 unique protocols at Mayo Arizona
- 2240 unique protocols in Mayo Arizona (~20,000 Mayo Enterprise)



Three years later ... Mayo AZ

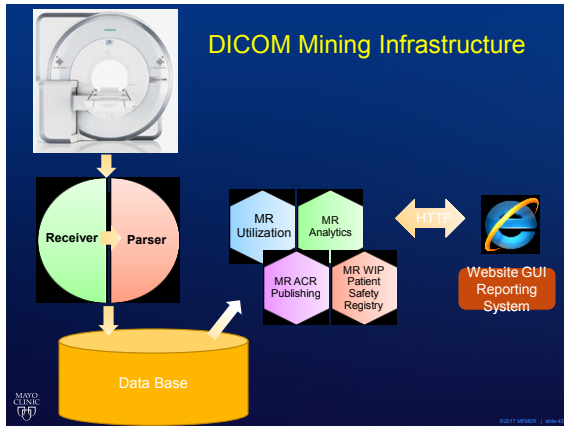
Consistent across ALL vendors and software versions

Mayo AZ

Mayo AZ

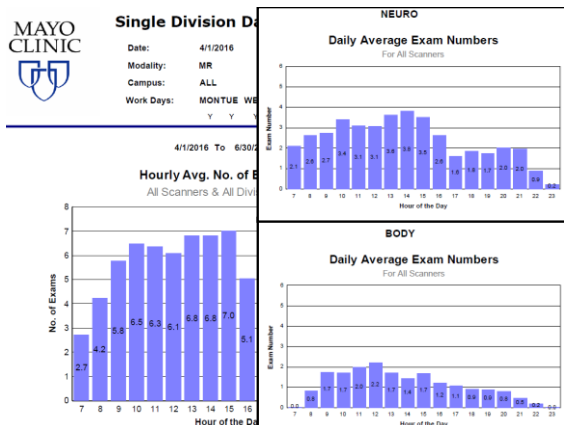
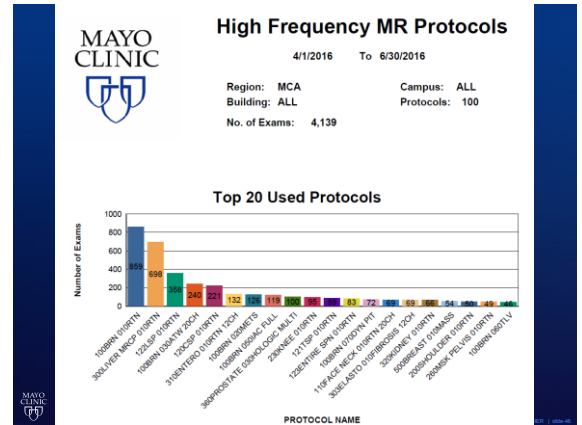
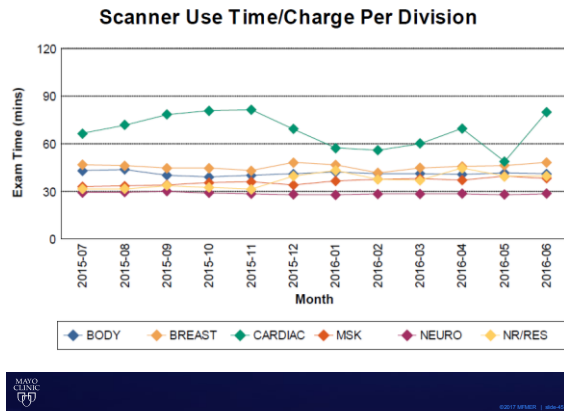
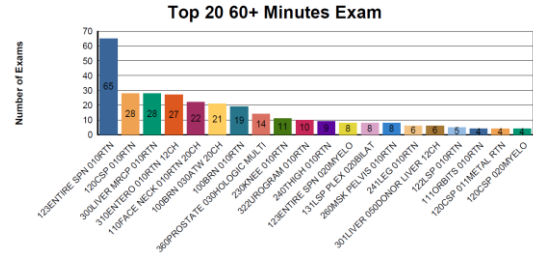
Mayo AZ

The diagram illustrates the DICOM workflow. It begins with a CT scanner on the left, followed by a sagittal MRI brain scan in the middle, and a screenshot of a DICOM file list on the right. Green arrows connect the scanner to the MRI scan, and the MRI scan to the file list. The word "DICOM" is written in large, outlined letters across the MRI scan and the file list.



MAYO CLINIC MR 60+ Minutes Exam

Date : 4/1/2016 To 6/30/2016
 Region: MCA Campus: ALL
 Building: ALL
 No. of Exams : 4987



MR Protocol Review - Opportunities

- Level 1: Required for accreditation under mandatory physicist supervision**
 - Parameter review for ACR physics phantom QC
 - Annual MR safety survey
 - Acoustic noise – GE Silent, Siemens Quite
- Level 2: Structured, needed for accreditation, medical physicists involvement not required**
 - ACR parameter review for clinical MR protocols
 - Low-SAR protocol development- Pacemakers, Neurostimulators
- Level 3: Neither well defined nor mandated, primarily research and clinical development activities**
 - Image acquisition optimization – fat sat, metal artifact reduction
 - New sequences, hardware, software
 - Operations Analytics: Consistency, Efficiency

MR Protocol Review

Level 1	• Required for accreditation under mandatory physicist supervision
Level 2	• Structured, needed for accreditation, medical physicists involvement not required
Level 3	• Neither well defined nor mandated, primarily research and clinical development activities
Level 3+	• Beyond clinical • Operations Analytics: Consistency, Efficiency

Medical physicist expertise beyond technical compliance to direct patient care and clinical operations \$\$

