July 1, 2013 ***From: Sachin Jambawalikar PhD***
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PHYSICS OF DIAGNOSTIC RADIOLOGY
LECTURE OUTLINE
2013 – 2014

A. FUTURE OF RADIOLOGY ABR EXAM

*The next ABR written exam will be given in **June 2014 (9th-10th and 12th -13th)**, and this will apply to our third year residents. The exam is called the "CORE" Examination. It is given after Radiology Residents have completed 36 months of training. The "CORE" exam will include about **600** questions covering clinical radiology imaging, radiology physics and radiation protection; it will take 1.5 days to be completed. The "CORE" exam will cover 6 Imaging Modalities + 2 Fundamental categories. The categories in the examination are listed below:*

1. *Projection X-ray Imaging: Radiography / Fluoroscopy*
2. *Interventional Radiology*
3. *CT*
4. *Ultrasound*
5. *MRI*
6. *Nuclear Medicine / Molecular Imaging*
7. *Radiology Physics*
8. *Radiation Biology / Radiation Protection / Regulatory Issues*

The ABR questions on the Fundamental categories will be directed towards the physics related to image quality, image formation, radiation dosimetry, radiation protection / safety, image artifacts and basic physics which affects image quality and radiation dose. The intent is to utilize questions that are clinically related to radiology imaging and practical in nature. It is estimated that more than 70% of the ABR examination in topics related to physics and radiation protection will be new questions that have never been previously used.

The "CORE" examination is also divided into 10 Organ System (anatomical areas) of clinical imaging. The clinical categories are listed below:

1. *Breast*
2. *Cardiac*
3. *Gastrointestinal (GI)*
4. *Muscular / Skeleton*
5. *Neurological*
6. *Pediatrics*
7. *Thorax*
8. *Endocrine / Reproductive Systems*
9. *Urological*
10. *Vascular*

*There will be at least **60** questions in each of these Organ Systems areas. Some of these questions in the clinical areas will include the physics related to image quality and to radiation dose / protection based upon clinical procedures and images. It is anticipated that a significant number of clinical images will appear in the ABR "CORE" exam.*

*Of the **600** question on the ABR "CORE" examination, at least **110** questions will be in radiology physics, and at least **60-82** questions will be in each of the other modality categories. The examination will be graded as "Pass" or "Fail" in each of the Organ Systems categories and in each of the Modalities + Fundamentals categories. A candidate must pass all categories in order to "Pass" the ABR "CORE" Exam. A candidate can fail up to 5 categories and be "Conditioned". A candidate who is "Conditioned" will have to retake the ABR "CORE" Examination in those categories in which he/she fails; the "CORE" examination is anticipated to be given at 6 month intervals. Candidates who fail more than 5 categories are considered to have "Failed" the entire "CORE" exam. These candidates who "Fail" must retake the entire ABR "CORE" candidates have a time limit of 5 years to successfully pass the "CORE" Examination.*

The final ABR "CERTIFICATION" examination will be an oral or computer examination on clinical topics which will be administered 15 months after the completion of a radiology residency training program. The oral examination can also include physics and radiation dosimetry/protection questions. Certification by the ABR in radiology will have a 10 year renewal cycle. Renewal of certification will include: Professional Standing (Licensure & current clinical practice), Lifelong Learning and Self Assessment (250 CME's + 20 SAM modules), Cognitive Expertise (an examination in selected specialty areas), Assessment of Performance in Practice (Practice Quality Improvement Project – PQI).

B. RADIOLOGY PHYSICS TEACHING APPROACH

*It is anticipated that many of the radiology physics and radiation dosimetry / protection questions on the ABR "CORE" Examination will come from web based teaching modules commissioned by the RSNA. Currently there are **46** physics modules completed and available for use. These RSNA physics teaching modules can be accessed by radiologists at the web site **http://www.rsna.org/education/physics.cfm**. The radiologists must be RSNA members in order to access this web site. However, radiology residents can become an RSNA member for "no cost – free" by just completing a questionnaire on the RSNA web site. Physicists who are AAPM members can access the physics teaching modules at the web site – **http://www.aapm.org/education/webbasedmodules.asp**. Upon completion of each physics teaching module, the web site will administer a short computer graded quiz. If the quiz is successfully passed, a printed certificate can be obtained.*

Each radiology resident will be expected to read the assigned modules corresponding to the topics being discussed in the scheduled lecture. These will be listed on the distributed syllabus of the physics course; radiology residents must print the certificates of successfully passing the assigned modules. These printed certificates will be used in place of oral or written quizzes to assess knowledge. Each radiology resident's competency for the assigned topic will be based upon the certificates from the RSNA web based modules. The certificates will be collected, and a record will be maintained in the radiology files to attest to successful completing the radiology physics instruction that is a mandated part of the resident training program.

The radiology physics teaching schedule is listed below along with the required reading and web based assignments. The schedule indicates which resident year must attend the assigned physics lectures. However, residents are encouraged to attend each of the assigned topics more than once in order to gain a better understanding of the various topics and in order to have the knowledge to perform better upon the ABR "CORE" Examination.

During the third year of Radiology resident training and prior to the ABR "CORE" Examination, physics will provide an extensive 20 hour (1 hour per day for four consecutive weeks) review of radiology imaging modalities, radiology physics and radiation dosimetry / protection / regulations. Discussion and Questions / Answers sessions will be a part of this physics review.

C. RSNA TEACHING MODULES

Fundamentals

1. *Atoms, Radiation, and Radioactivity*
2. *Interactions of Radiation and Tissue*
3. *Radiation Measurements and Units*
4. *X-ray Tubes and Spectra*

Basic Imaging Science and Technology

5. *Foundations of Medical Image Quality: Contrast, Sharpness, and Noise*
6. *Evaluation and Derivatives of Medical Image Quality*
7. *Image Perception and Performance Evaluation Including CAD*
8. *Image Display*
9. *Image Processing and Reconstruction*
10. *PACS* *- new -*

Radiation Biology

11. *Basic Radiation Biology*
12. *Radiation Effects*

Radiation Protection

13. *Fundamentals of Radiation Protection*
14. *Radiation Dose and Risks*
15. *Radionuclide Dosimetry and Nuclear Regulations*

Projection X-Ray Imaging

16. *Basic Concepts in Radiography*
17. *Basics of X-ray and Mammographic Systems*
18. *Digital X-ray Imaging*
19. *Radiographic Image Receptors*
20. *Image Quality and Dose in Radiography*
21. *Image Quality and Dose in Mammography*

Fluoroscopy

22. *Fluoroscopy Systems*
23. *Radiation Dose and Safety in Interventional Radiology*

Computed Tomography

24. *CT Systems*
25. *CT Image Quality and Protocols*
26. *Radiation Dose in CT*
27. *Image Gently – CT imaging & radiation protection standards* *- new -*

Ultrasound

28. *Ultrasound – Concepts and Transducers*
29. *Basic Ultrasound Imaging and Display*
30. *Interaction of Ultrasound Tissue and Doppler*
31. *Image Quality-Artifacts-Doppler-Safety*

Magnetic Resonance

32. *Basic Principles of Nuclear Magnetic Resonance*
33. *MRI: Image Formation*
34. *MRI: Image Characteristics*
35. *MRI: Pulse Sequences*
36. *MRI: Instrumentation*
37. *MRI: Image Artifacts*
38. *MRI: Special Acquisition Methods*
39. *MRI: Tissue Properties, Contrast Agents and Reactions*
40. *MRI: Quality/Bioeffects/Safety*
41. *MRI: Siting and Environmental Protection*

Nuclear Medicine

42. *Radiation Detection Instrumentation in Nuclear Medicine Practice*
43. *Gamma Cameras / Image Quality*
44. *Nuclear Medicine: Radioisotopes and Radiopharmaceuticals*
45. *SPECT / SPECT-CT / Image Quality*
46. *PET / PET-CT / Image Quality*

D. TIME, LOCATION & FORMAT

*Lectures in the Physics of Diagnostic Radiology for First Year Radiology Residents will be given each week on **Monday from 1:30-2:30pm**, commencing **July 8, 2013** (Monday). The lectures will be held in the Radiology Teaching Conference Room #3-303 (on Harkness-3). While conference room is being refurbished, lectures will be in Radiology Library. If the conference room is occasionally not available, other arrangements will be made for these dates. The lecture series will continue until **May 19, 2014**. The tentative lecture schedule is listed below along with the presenter and topic (Unless Notices Are Posted Changing the Time, Date or Location of the Lectures).*

*There are only three years to learn concepts, equipment, radiation safety, image quality, radiation biology, MRI, CT Ultrasound, Computers and Radiation Dosimetry. Physics also benefits Radiology Residents by providing a basis for a better understanding of clinical procedures and radiation safety. Licensure by various States and the **NRC require** proof of attendance of at least **200 hours** of physics during training. Attendance sheets will be collected at these lectures and Chief Residents, the Chairman, and Dr. Rozenshtein will be notified of poor attendance records. If no Radiology Residents arrive 15 minutes after the scheduled starting time or less than three (3) Residents attend a given lecture, that lecture will be cancelled. If the overall attendance drops below 50% on several consecutive lectures, Physics will assume that the Radiology Residents do not require these lectures and the Physics Review Sessions will be drastically reduced or cancelled.*

E. REFERENCES

The principle reference textbooks for this lecture series will be:

1. **Nickoloff EL, Radiology Review: Radiologic Physics, Elsevier/Saunders, Publishers ISBN 1-4160-2260-0, 2005 (**Shown as ELN in schedule**)*
2. *JT Bushberg, JA Seibert, EM Leidholdt, Jr. and JM Boone. The Essentials of Physics of Medical Imaging, 3rd, Williams & Wilkins, 2012.*
3. *Wolbarst AB, Physics of Radiology. Appleton & Lange, 2005.*
4. *Huda W, Stone RM, Review of Radiologic Physics, 3rd, Williams & Wilkins, 2012.*
5. *Hendee W, and Ritenour R, Medical Imaging Physics, 4th ed. Wiley-Liss, 2002.*

For the Nuclear Medicine portion of the course, reference textbooks are:

1. *Physics in Nuclear Medicine by SR Cherry, JA Sorenson and ME Phelps, Grune & Stratton, 2003.*
2. *Henkin R et al. Nuclear Medicine, Mosby, 2006.*
3. *Mettler FA and MJ Guiberteau, Essential of Nuclear Medicine Imaging 2006.*
4. *Introduction Physics of Nuclear Medicine by R. Chandra, Lea & Febiger 2004 are recommended.*

Additional suggested readings and notes may be provided during the course.

Please mark your calendars to indicate the start of this lecture series.

F. SCHEDULE

See new schedule

6/6/2013

2013-2014 RESIDENTS' PHYSICS LECTURES

(Lecture time: All Mondays – 1:30 pm-2:30pm, except two on Tuesday after the Martin Luther King, Jr. Day and Presidents' Day)

All Residents for Each of Three Years

Date	Lecturer		Topic	RSNA Module #
7/08/13	Liang	1	Radiation Units (Exposure, Air Kerma, Absorbed Dose, Dose Equivalent, Critical Organ Dose, Fetal Dose, Effective Dose) and Typical Values	#3 (ELN Ch. #14)
7/15	Liang	2	Factor which affect Patient Radiation Doses	#13 (ELN Ch. #14)
7/22	Liang	3	Biological Effects of Radiation (Macroscopic Acute & Latent Effects)	#11, 12 (ELN Ch. #15)
7/29	Liang	4	Radiation Safety Practices, Permissible Radiation Levels (Staff & Patients), Radiation Badges & Regulatory Limits (Fluoroscopy, CT & NYS Radiographic Limits)	#13, 14, 15 (ELN Ch. #14)

Primarily for First Year Residents

Date	Lecturer		Topic	RSNA Module #
8/05	Jambawali kar	5	Review of Basic Physics: Atomic Structures, Electricity & Magnetism, Energy, Electromagnetic Waves and their Quantum Nature - Differences between Photons and Particulate Radiation	#1 (ELN Ch. #1)
8/12	Liang	6	Production of X-rays (Bremsstrahlung and Characteristic X-rays) and Interactions of X-ray Radiation with Matter	#2, 4 (ELN Ch. #4, 6)
8/19	Liang	7	X-ray Equipment: X-ray Tubes, Generator, kVp's mAs, Filters, HVL, kVp Waveforms, Grids and Collimators related to Image Quality and Patient Radiation Doses	#17 (ELN Ch. #2,3,5,7,8)
8/26	Jambawali kar	8	Imaging Concepts: Differential X-ray Attenuation, Scattered Radiation & Contrast, Image Blur (Unsharpness)	#5, 16 (ELN Ch. #13)
9/9	Jambawali kar	9	Measures of Image Quality: Spatial Resolution, MTF, SNR, Mottle (noise),CNR	#6 (ELN Ch. #13)
9/16	Jambawali kar	10	Image Processing and Reconstruction, CAD	#7, 9 NONE
9/23	Liang	11	Image Display and PACS	#8, 10 (ELN Ch. #12)
9/30	Liang	12	The Image Receptor (Analog & Digital) and its Effect upon Image Quality	#18, 19 (ELN Ch. #12)
10/7	Liang	13	Radiation Doses & Safety in Radiography (DRL, ED) Scoliosis Filter; Repeat Rates, Protection	#20 (ELN – CD)
10/14	Liang	14	Introduction to Fluoroscopy: The Equipment (Image Intensifier, Flat Panel Detector (FPD), Television System, Display Monitor)	#22 (ELN Ch. #16)
10/21	Liang	15	Fluoroscopy: Image Quality (pulse rate, ABC, dose selection, FoV)	#22 (ELN Ch.#16+CD)
10/28	Liang	16	Fluoroscopy, Radiation Doses and Radiation Risks	#23 (ELN Ch. #16)

Primarily for Second Year Residents

Date	Lecturer		Topic	RSNA Module #
11/04/13	Liang	17	Introduction to Mammography: X-ray Tube, Filters, Focal Spots, X-ray Spectra, Magnification, Concept of Average Glandular Dose	#17 (ELN Ch. #17)
11/11	Liang	18	Mammography Equipment: Analog vs. Digital Image Receptors	#17 (ELN Ch. #17)
11/18	Liang	19	Mammography Image Quality, Radiation Doses & Risks	#21 (ELN Ch. #17)
11/25	Liang	20	Computed Tomography: History, Terminology and Basics	24 (ELN Ch. #18)
12/02	Liang	21	Computed Tomography: Reconstruction Processes, Algorithms and Effect upon Image Quality	24 (ELN Ch. #18)
12/09	Liang	22	Computed Tomography: Image Quality and Artifacts	#25 (ELN Ch. #18)
12/16	Liang	23	Computed Tomography: Radiation Dose Terminology, Typical Values and Radiation Risks	#26, 27 (ELN Ch. #18)
1/06/14	Liang	24	Ultrasound Basics: Basic Concepts, Transmission, Reflection, Absorption, Scatter and Impact on Image Quality Ultrasound Equipment: Sector, Linear Array, Phased Array, Special Probes, Doppler Scanners, Equipment Limitations upon Image Quality	#28,30 (ELN Ch. #19) #29, 30 (ELN Ch. #19)
1/13	Liang	25	Ultrasound Artifacts and Potential Bio-risks	#31 (ELN Ch. #19)
4/14/2014	Jambawalikar	26	Nuclear Medicine: Radiation Detection Instrumentation	#42
4/21	Jambawalikar	27	Nuclear Medicine: Radioisotopes and Radiopharmaceuticals Nuclear Medicine: Patient Dosimetry & Safety	#44
4/28	Jambawalikar	28	Nuclear Medicine: Gamma Cameras/ Image Quality	#43
5/5	Jambawalikar	29	Nuclear Medicine: SPECT/SPECT-CT/Image Quality	#45
5/12	Jambawalikar	30	Nuclear Medicine: PET/PET-CT/Image Quality	#46

(Please Note: Nuclear Medicine courses for second year residents are scheduled in April)

Primarily for Third Year Residents

Date	Lecturer		Topic	Module #
1/21/14 (Tuesday)	*Jambawalikar*	*31*	*Angiography Equipment: Features Impact on Image Quality and Radiation Dose and Cardiac Angio: Special Features, Radiation Doses and Potential Bio-Effects Special Cardiac and Neuro CT – CTA, CT perfusion, Cardiac CT scoring and Dual energy*	*#23* *NONE*
1/27	*Jambawalikar*	*32*	*Introduction to MRI: Basic Physicis, Proton Magnetic Moment, Larmour Frequency, FID and Relaxation Times*	*#32*
2/3	*Jambawalikar*	*33*	*MRI: Image Formation*	*#33*
2/10	*Jambawalikar*	*34*	*MRI: Image Characteristics and Factors affecting Image Quality*	*#34*
2/18 (Tuesday)	*Jambawalikar*	*35*	*MRI:Pulse Sequences*	*#35*
2/24	*Jambawalikar*	*36*	*MRI: Instrumentation*	*#36*
3/3	*Jambawalikar*	*37*	*MRI: Image Artifacts*	*#37*
3/10	*Jambawalikar*	*38*	*MRI: Special Acquisition Methods*	*#38*
3/17	*Jambawalikar*	*39*	*MRI: Tissue Properties Contrast Agents and Reactions*	*#39*
3/24	*Jambawalikar*	*40*	*MRI: Fluid Flow and MRA* *MRI: MR Spectroscopy*	*#38*
3/31	*Jambawalikar*	*41*	*MRI: Quality/Bioeffects/Safety* *MRI: Siting and Environmental Protection*	*#40, 41*
4/7	*Jambawalikar*	*42*	*Statistics in Radiology: Decision Matrix, ROC, Sensitivity, Specificity, Accuracy, PPV, NPV, Correlation and Others*	*NONE*
4/14/14- 5/16/14	***ALL***	*43*	*Review for ABR "CORE" Exam (20 hrs)* *(One hour per day for **20** days)* ***Time:** 3:00-4:00pm or 4:00-5:00pm*	
			2014 ABR "core" exam starts on June 9, 2014	

*An Additional detailed schedule for the **ABR CORE Review** will be provided to 3rd Year residents in Feb 2014*

Holidays (fall on Mondays) are

2013

9/2 - Labor Day

2014

1/20/14 - Martin Luther King, Jr. Day

2/17/14 - Presidents' Day