**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” exam. 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:


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


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
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

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

Primarily for First Year Residents

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

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

(Please Note: Nuclear Medicine courses for second year residents are scheduled in April)
<table>
<thead>
<tr>
<th>Date</th>
<th>Lecturer</th>
<th>Topic</th>
<th>Module #</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/21/14</td>
<td>Jambawalikar</td>
<td>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</td>
<td>#23</td>
</tr>
<tr>
<td>1/27</td>
<td>Jambawalikar</td>
<td>Introduction to MRI: Basic Physics, Proton Magnetic Moment, Larmour Frequency, FID and Relaxation Times</td>
<td>#32</td>
</tr>
<tr>
<td>2/3</td>
<td>Jambawalikar</td>
<td>MRI: Image Formation</td>
<td>#33</td>
</tr>
<tr>
<td>2/10</td>
<td>Jambawalikar</td>
<td>MRI: Image Characteristics and Factors affecting Image Quality</td>
<td>#34</td>
</tr>
<tr>
<td>2/18</td>
<td>Jambawalikar</td>
<td>MRI: Pulse Sequences</td>
<td>#35</td>
</tr>
<tr>
<td>2/24</td>
<td>Jambawalikar</td>
<td>MRI: Instrumentation</td>
<td>#36</td>
</tr>
<tr>
<td>3/3</td>
<td>Jambawalikar</td>
<td>MRI: Image Artifacts</td>
<td>#37</td>
</tr>
<tr>
<td>3/10</td>
<td>Jambawalikar</td>
<td>MRI: Special Acquisition Methods</td>
<td>#38</td>
</tr>
<tr>
<td>3/17</td>
<td>Jambawalikar</td>
<td>MRI: Tissue Properties Contrast Agents and Reactions</td>
<td>#39</td>
</tr>
<tr>
<td>3/24</td>
<td>Jambawalikar</td>
<td>MRI: Fluid Flow and MRA MRI MR Spectroscopy</td>
<td>#38</td>
</tr>
<tr>
<td>3/31</td>
<td>Jambawalikar</td>
<td>MRI: Quality/Bioeffects/Safety MRI Siting and Environmental Protection</td>
<td>#40, 41</td>
</tr>
<tr>
<td>4/7</td>
<td>Jambawalikar</td>
<td>Statistics in Radiology: Decision Matrix, ROC, Sensitivity, Specificity, Accuracy, PPV, NPV, Correlation and Others</td>
<td>NONE</td>
</tr>
</tbody>
</table>
| 4/14/14-5/16/14 | ALL     | Review for ABR “CORE” Exam (20 hrs)  
(One hour per day for 20 days)  
**Time:** 3:00-4:00pm or 4:00-5:00pm | NONE     |

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