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Please note that this guide is NOT to be used in place of a textbook.

NUCLEAR MEDICINE ROTATION EXPECTATIONS:

1. **Be on time.** Please be in the reading room by 8 AM, unless you have lecture. If you can’t be on time or are sick, please let us know as soon as you know.
2. **Be engaged.** Our evaluations are based on your participation, so please be actively engaged and stay on task.
3. **Ask questions.** You’re paid to learn. If something doesn’t make sense, please ask. You’re the master of your own destiny and every opportunity is what you make of it.
4. **Read.** No one can hope to learn all of nuclear medicine on their rotations alone. In order to supplement your education, you need to read a text (Essentials of Nuclear Medicine Imaging by Mettler and Guiberteau or Nuclear Medicine: The Requisites by Zeissman, O’Malley and Thrall; other case review books are also recommended.) You will get some time to read during the mornings when the radiopharmaceuticals are localizing, but evening reading is expected. Please note that these texts are available through our library.
5. **Visit the NM website.** This will let you see video lectures on specific topics as well as must read papers, etc. Make every effort to visit this on a regular basis.
6. **Attend lectures.** From August to June, we will have regularly scheduled morning lectures. You are expected to attend. For more information, please see #9 of housekeeping issues below.
7. **Spend time in the hot lab & seeing how images are acquired.** For many, seeing it in person than reading it in a book helps to have things make more sense.
8. **Please ask for feedback.** Each Friday we will try to have “Feedback Friday”, but the resident needs to start the conversation when the time is right. Please take the opportunity to do this. Feedback isn’t always what we want to hear, but it helps all of us to get to the next level.

CALL EXPECTATIONS:

1. **Do the best you can.** It is inevitable that during training you will miss something but do the best you can for the patient. In this “Survival Guide” you will find things that may assist you, but this is not a replacement for a textbook.
2. **Don’t forget that you can call the attending on call.** If you can’t figure something out or you need help, you can always call us. You can ask the technologist or check the call schedule on QGenda to see which attending is on call.
3. **If you have a question on how the final report reads, ask.** There is a tool to look at tracked changes in a report. Please do this on a regular basis to see how you can improve your reports. To maximize this experience, ask or email any questions you may have.
4. **Compare to the prior.** This is considered a quality measure for attending reports, so start now. Also, nothing makes you look smarter than old films.
5. **Be respectful and kind to everyone, and especially to the on-call NM technologist.** Not that you wouldn’t, but sometimes they mention things like this to the NM attendings. Remember that they’ve been doing this for years and deserve the respect & kindness owed any professional colleague.
**NM FACULTY CONTACT INFORMATION:**

<table>
<thead>
<tr>
<th>Name</th>
<th>Web page ID #</th>
<th>Cell phone</th>
<th>Email</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dr. Bruce Barron</td>
<td>16404</td>
<td>770-688-5749</td>
<td><a href="mailto:BJBBarro@emory.edu">BJBBarro@emory.edu</a></td>
</tr>
<tr>
<td>Dr. Yoram Baum</td>
<td>40759</td>
<td>404-862-8034</td>
<td><a href="mailto:Ybaum@emory.edu">Ybaum@emory.edu</a></td>
</tr>
<tr>
<td>Dr. Dacian Bonta</td>
<td>16292</td>
<td>773-968-7175</td>
<td><a href="mailto:Dacian.bonta@emoryhealthcare.org">Dacian.bonta@emoryhealthcare.org</a></td>
</tr>
<tr>
<td>Dr. David Brandon</td>
<td>17555</td>
<td>404-218-1339</td>
<td><a href="mailto:David.brandon@emoryhealthcare.org">David.brandon@emoryhealthcare.org</a></td>
</tr>
<tr>
<td>Dr. Erin Grady</td>
<td>40971</td>
<td>708-860-6216</td>
<td><a href="mailto:Erin.grady@emory.edu">Erin.grady@emory.edu</a></td>
</tr>
<tr>
<td>Dr. Raghu Halkar</td>
<td>20106</td>
<td>404-457-4732</td>
<td><a href="mailto:rhalkar@emory.edu">rhalkar@emory.edu</a></td>
</tr>
<tr>
<td>Dr. Lance Hall</td>
<td>85098</td>
<td>239-834-2300</td>
<td><a href="mailto:Lance.t.hall@emory.edu">Lance.t.hall@emory.edu</a></td>
</tr>
<tr>
<td>Dr. Jerry Hernandez</td>
<td>47494</td>
<td>404-917-3231</td>
<td><a href="mailto:Jeranfel.hernandez@emory.edu">Jeranfel.hernandez@emory.edu</a></td>
</tr>
<tr>
<td>Dr. Valeria Moncayo</td>
<td>10565</td>
<td>404-520-5803</td>
<td><a href="mailto:vmoncay@emory.edu">vmoncay@emory.edu</a></td>
</tr>
<tr>
<td>Dr. Saima Muzahir</td>
<td>86338</td>
<td>319-331-4084</td>
<td><a href="mailto:Saima.muzahir@emory.edu">Saima.muzahir@emory.edu</a></td>
</tr>
<tr>
<td>Dr. Cesar Santana</td>
<td>14451</td>
<td>404-429-9454</td>
<td><a href="mailto:csantan@emory.edu">csantan@emory.edu</a></td>
</tr>
<tr>
<td>Dr. Trey Schroeder</td>
<td>54292</td>
<td>205-807-0375</td>
<td><a href="mailto:Hary.william.schroeder@emory.edu">Hary.william.schroeder@emory.edu</a></td>
</tr>
<tr>
<td>Dr. David Schuster</td>
<td>11161</td>
<td>404-664-5772</td>
<td><a href="mailto:dschust@emory.edu">dschust@emory.edu</a></td>
</tr>
<tr>
<td>Dr. Ila Sethi</td>
<td>11161</td>
<td>404-664-5772</td>
<td><a href="mailto:Sila2@emory.edu">Sila2@emory.edu</a></td>
</tr>
<tr>
<td>Dr. Amol Talkakar</td>
<td>106932</td>
<td>318-210-4334</td>
<td></td>
</tr>
</tbody>
</table>
“Housekeeping” issues for NM residents:

1. Education Team

   In a way the entire faculty and your co-trainees are your education team, but some people have official roles:
   
   Dr. Grady, Program Director
   Dr. Brandon, Associate Program Director
   Ranitta McDowell, Program Coordinator

2. Radiation Exposure Record

   Changing film badges monthly is the responsibility of each resident. The previous month badge must be returned to the Radiation Safety box in the mailroom at the Emory Hospital by the 10th of that current month.

   Radiation tracking is performed by our Emory Radiation Safety Officer, Ike Hall. If you have any questions you may contact him at ihall@ehso.emory.edu. Radiation safety is a lifelong process. **WEAR YOUR DOSIMETRY BADGES.**

3. Parking

   Policies vary by hospital. Check with the Residency Program Office if you have questions. Parking access cards for Emory and Grady will be received during GME orientation. Monthly parking charges for both facilities are paid by the GME. EUH Midtown parking access is via your Emory card. This must be activated by the EUH Midtown security office by you directly. The Cliff shuttle is also offered for transportation to both Grady and Emory University Hospital Midtown from Emory Hospital. Schedules are available at [http://transportation.emory.edu/shuttles/index.html](http://transportation.emory.edu/shuttles/index.html)

4. Communications

   Email is the primary method for communication by the residency program office and GME. Your [emory.edu](http://www.emory.edu) accounts are assigned by GME and must be checked “daily.” Your physical mailbox at EUH will be used for important but less urgent communication. Please check and empty your mailbox often; if you cannot do this, please arrange for someone to check it for you. You can also link your emails to your smartphone.

5. Dress Code

   While working at any of our facilities during normal business hours, you are expected to dress professionally.
6. **Telephone Systems**

You may call directly on outside line or on Tie Line using prefix numbers plus four-digit extension.

<table>
<thead>
<tr>
<th>Tie Line</th>
<th>Main Numbers</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>Emory University</td>
</tr>
<tr>
<td>2</td>
<td>Emory University Hospital</td>
</tr>
<tr>
<td>8</td>
<td>Emory Clinic</td>
</tr>
<tr>
<td>6</td>
<td>Emory University Hospital Midtown</td>
</tr>
<tr>
<td></td>
<td>Grady Memorial Hospital</td>
</tr>
<tr>
<td></td>
<td>CHOA</td>
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<td></td>
<td>VAMC</td>
</tr>
</tbody>
</table>

Simon Paging System, 404-686-5500 or 6-5500 (then follow instructions)

7. **Schedules & Pagers**

The chief resident will distribute the monthly rotation and call schedules, a small number of changes are unavoidable and should be anticipated; notification of these will be made. Any proposed change that you might have must be handled through the chief resident and program director. There are 13 rotations per year. Each rotation is approximately 4 weeks.

Pagers- you will have the same assigned number for three years. If your pager is lost or broken, you will be charged $300.00 for a replacement.

8. **New Innovations Evaluations & Duty Hours**

Resident evaluations are completed by the faculty and other divisions as a group at the end of each rotation. The New Innovations welcome screen also will alert you when you have new evaluations to complete or sign. In addition, copies are available in the Residency Program Office at any time for your review.

**Instructions for Faculty Evaluations**

At the end of each rotation, residents have the opportunity to *anonymously* evaluate individual faculty as well as the rotation and the program as a whole.

Go to [https://www.new-innov.com/login/](https://www.new-innov.com/login/) enter the hospital as “EMORY” (all caps), your log in info all lowercase. Log into the site using the login and password provided to you. You will be greeted with a
message telling you the number of your evaluations that are incomplete. Follow the links to complete the evaluations. Resident evaluations of faculty are anonymous.

Duty Hours are very important to the residency program requirements. You must log your Duty Hours daily if not weekly into New Innovations. Use the login information above to get into the system, click on the Duty Hours tab to start logging your hours.

9. Conference and Lectures
   • Grand Rounds/Wednesday
     Given by the department on Wednesdays at 7:30 AM, attendance is mandatory. For AY 20-21, this will be fully remote.
   • Monday/Tuesday/Friday
     These lectures will begin at 7:30AM and will be held at either the VA or at EUH in N120 (usually). The calendar on New Innovations will be up to date for your reference and you will also receive a monthly calendar via email.
   • Physics/Thursday
     These lectures will be given on Thursdays in N120 from 7:30AM – 9:00AM by one of the physics attendings.

   **Required Text:** Essentials of Nuclear Medicine Physics and Instrumentation (3rd Ed) by R. Powsner, M. Palmer, and E. Powsner

   **Recommended Text:** Physics in Nuclear Medicine by Cherry, Sorenson, and Phelps

   You must complete the Conference Survey in New Innovations after each conference (with the exception of Grand Rounds) is given. You will receive an email from New Innovations when the survey is available for completion.

   You are required to document your attendance in New Innovations.

10. Leave Policy
    Each resident has a total of 15 vacation days to be used over the course of the year.

    Residents may take up to 5 consecutive days off within a single rotation block. If residents want to take more than 5 consecutive vacation days at a time, they must request a period that overlaps two rotation blocks such that no more than 5 days are taken from a single block.

    Please note that meeting time counts toward total time off per rotation. In other words, if a resident takes 3 days off to attend a conference, he or she can take only 2 additional days off during that rotation.

        1. All vacation requests require submission of a Time Off Request Form, made available by Ranitta
        2. Vacation requests must be submitted for approval to all of the following:
           a. Chief Residents (by email/Qagenda)
b. Attending of rotation vacation is to take place
c. Ranitta

3. Vacation requests must be submitted a minimum of 15 days in advance for all rotations.
4. The staff preceptors and Chief Resident will approve vacation requests based on staffing and coverage needs. After signatures of authorization have been obtained, Dr. Grady will approve requests pending resident completion of administrative responsibilities.
5. Vacation approval is not final until all designated individuals, including the Program Director, have given email or written approval. Any resident who is away without documentation of final approval will be charged an extra day of vacation for each unauthorized day absent.
6. Residents will be notified of final approval by the Chief.
7. If the dates of the requested vacation are changed, residents must inform the Chief Resident, the division staff preceptor, and Ranitta.
8. Vacation will be limited during the following periods:
   a. Major conferences and annual meetings, e.g. RSNA, SNMMI, AUR

11. Sick days
   Residents who need to be absent from work due to illness must do all of the following:

   1. Email the Chief Resident to state you will be out sick.
   2. Call the reading room where you are working and speak to either the reading room coordinator or an attending.
   3. Send email to Ranitta and Dr. Grady so that they are aware.

12. Moonlighting
   Currently internal moonlighting is not permitted due to COVID.

   You must obtain written approval from the Program Director semiannually. The moonlighting request form and Emory House Staff Policies are available at the GME website at https://med.emory.edu/education/gme/housestaff/housestaff_policies/section6.html.

   Residents who wish to pursue external moonlighting must submit proof of independent malpractice coverage along with their request.

   Both internal and external moonlighting hours count toward ACGME duty hour limits and must be logged appropriately in New Innovations.

   Moonlighting activities must be compatible with a resident’s visa status.

   In addition to the requirements below, the Program Director or his/her designee’s decision to approve or deny a resident’s request to moonlight will depend on a number of factors including, but not limited to, interference with the resident’s responsibilities in the training program and the individual circumstances of the resident.
13. Sleep and fatigue
Residents working extended hours should be aware of their fatigue levels and potential for functional impairment. Currently, our GME office has a contract with Lyft, to provide rides home for residents who feel they are too tired to drive safely.

14. Scholarly Activity
Resident must keep track of all SA and submit to Ranitta upon request. If you have made any changes to your CV please send updated version to Ranitta via email.

15. Georgia Training Permit
All new residents are required to have a Georgia Resident Training Permit or a full unrestricted license. This application will be sent yearly to our office by the GME for renewal and the cost will be covered by the GME. If you desire a Georgia medical license, you must apply on your own after passing USMLE Step 3. GME will reimburse you up to $100.00 for the cost of the medical license with proof of payment. As above, at least a full unrestricted state license and additional malpractice coverage is required to moonlight externally.

16. BLS/ACLS
You must be current and keep these updated. In accordance with the ACGME requirements all residents must be certified in BLS (Basic Life Support). Certification in ACLS (Advanced Cardiac Life Support) is also required by our GME office.

BLS and ACLS can be scheduled through contacting Kim Fugate, Director of the Sim Center kim.fugate@emory.edu. There will be online modules to complete within 45 days plus a thirty minute testing time. If you do not complete this within 45 days you will be charge $150.00, license is otherwise covered by GME.

Monthly BLS courses offered by Grady Memorial Hospital (call Ms. Angela Thompson 5-5308). Updated cards are a must at Grady.

All new residents must be BLS/ACLS certified no later than September 30 of the current academic year in order to be in compliance with the minimum program requirements.

The Emory Office of GME requires all residents to maintain current certification to work. Evidence of re-certification must be furnished to the Residency Program Office, along with new expiration date. An email invite will be sent to you as a reminder.

17. Computer Systems— 8-HELP
All calls for PACS, PowerScribe, and RADNET should go through 8-HELP or 404-778-HELP from the outside.
For all escalated issues

Betsy Barber  Karen Boles
937-307-4674  404-313-7857 or 2-5812

Additional contact numbers

PowerScribe  404-616-1715 (Voice Recognition Dictation System)
PACS  678-614-3987 (This is Grady IT support number)
Stat Dx  801.485.6500 Technical Support Email: support@amirsys.com
Mark Lee  404-616-5257 (Grady)
Elizabeth Ross  404-616-0551 (Grady)

IBM PC’s (located in the Sybers Library at Grady and Emory Residents’ Office at Emory Hospital for Intranet access. Internet access on PC’s in reading rooms for an educational purpose is appropriate. Other internet activities should be avoided).

18. Department Library
Room N119- 404-712-7020 or 404-712-7942 (key card access only).

19. Division of Nuclear Medicine website
http://radiology.emory.edu/education/nuclearmedicineres.html (here you can find a list of faculty and other facts about the division)

20. Policies & Procedures and Goals and Objectives - These are disseminated separately and also within New Innovations.

21. FSAP
Counseling Service is available through the Medical School for any resident with personal or professional concerns. Information is available online at www.emory.edu/fsap or at 404-727-4328.

22. Fitness Options
Woodruff PE Center Emory Campus www.wpec.emory.edu will give you information concerning hours, etc.
DON’T FORGET THE AMERICAN COLLEGE OF GRADUATE MEDICAL EDUCATION (ACGME) CORE COMPETENCIES:

1. Patient care
2. Medical knowledge
3. Practice based learning & improvement
4. Interpersonal skills and communication
5. Professionalism
6. Systems-based practice
CALL GUIDE:
Call hours M-F 5-10 pm and holidays and weekends 8 am -10 pm.

The studies we read one call are the following:

HIDA, VQ, GI Bleeding scan, Brain Death Study, and Cardiac studies at EUH if they are CDU patients, if the cardiac patients are floor patients, a cardiologist must be willing to stress the patient for it to be done.

All weekend studies from Grady need to be finalize prior to Monday AM.

Up to 6 PET/CTs studies will be done on Saturdays; please be proactive in assisting.

Anything else can wait until the next business day.

Remember the techs are not in house they get called in from home.

The Techs are usually paged first for exams, but in the event the ordering provider pages you, return the page and find out the patient’s name, what study they want done and reason for it and any other pertinent information.

Any general nuclear medicine studies that are completed between the hours of 10 PM and 8am should be read out by the in house on call radiology resident at midtown and finalized by the radiology attending. In the event that it doesn’t get finalized by a radiology attending, you should finalize it.

Technologist phone numbers:

<table>
<thead>
<tr>
<th>EUH Techs</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Angela Akbashkeva</td>
<td>404-931-8794</td>
</tr>
<tr>
<td>Jim Fitz</td>
<td>C: 707-410-9035 H: 678-344-1282</td>
</tr>
<tr>
<td>Valerie Frederick</td>
<td>404-422-0076</td>
</tr>
<tr>
<td>Kim Harper</td>
<td>478-457-5076</td>
</tr>
<tr>
<td>Eric Husband</td>
<td>404-210-7782</td>
</tr>
<tr>
<td>Fabian Simmons</td>
<td>318-458-7751</td>
</tr>
<tr>
<td>Eric Svancara</td>
<td>208-226-4693</td>
</tr>
<tr>
<td>Tajan Wisdom</td>
<td>762-209-9461</td>
</tr>
</tbody>
</table>

EUH Tech hallway number is 404-712-5017.

Always check EH Connect to see who is on call with you.

<table>
<thead>
<tr>
<th>EUHM Tech</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kitanya Farmer</td>
<td>404-313-2430</td>
</tr>
</tbody>
</table>
Nancy Hicks 404-317-8592
Kawai Laurencin 678-353-8500

EUHM Tech hallway number 404-686-1225
Check EH Connect to see which tech is on call.

Grady Lead Tech: Mr. Sebastian Chimafor 678-524-3183, call him only if you can’t get into the Grady reading room on the weekends. Although you should have access to it.

Grady Tech Room 404-616-4602 or 404-616-8820

Trainee phone numbers:

<table>
<thead>
<tr>
<th>RESIDENT</th>
<th>NUMBER</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alexy Babak (MIM)</td>
<td>346-323-1142</td>
</tr>
<tr>
<td>Jitesh Dhingra (NM)</td>
<td>551-263-2110</td>
</tr>
<tr>
<td>Josh Jadwin (DR/MIM)</td>
<td>585-610-6627</td>
</tr>
<tr>
<td>Jed Kendall (DR/MIM)</td>
<td>435-660-0958</td>
</tr>
<tr>
<td>Robson de Macedo Filho (NM)</td>
<td>954-995-4784</td>
</tr>
<tr>
<td>Domnique Newallo (NM, chief)</td>
<td>551-263-2110</td>
</tr>
<tr>
<td>Gbenga Shogbesan (NM)</td>
<td>443-854-4043</td>
</tr>
<tr>
<td>Chenxi (Chelsea) Wu (MIM)</td>
<td>214-223-1834</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>FELLOW</th>
<th>NUMBER</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yamil Fourzali</td>
<td>470-775-5328</td>
</tr>
<tr>
<td>Charles Marcus</td>
<td>443-831-7942</td>
</tr>
<tr>
<td>Bo Chen</td>
<td>210-355-6348</td>
</tr>
</tbody>
</table>
**Accessing Grady On Call:**

Remote access to the Grady NM workstation can be obtained from the below link:

https://citrixnet7.gmh.edu/vpn/index.html

When you log in, click on the remote PACsWi...360 icon,

Then click on the Intellispace PACS radiology icon and log into that. Power scribe should automatically open up once you are logged in.

Pick “Attending, Overnight” as your attending; this was

1. To review MPI cardiac studies – Using Shift key highlight AUTOQUANT Results and send it to Phillips application, then click on Autoquant 2012 (see below illustrations. Now you will get the full version of the cardiac viewer that allows you to see gated studies and all the views that you are able to see in Grady NM reading room work station. Once done use the EXIT on the lower left hand side of the screen.
2. To view V/Q SPECT studies – Using the Shift Key highlight both Perfusion and Ventilation transverse slices and send it to Philips application and then click on NM VIEWER. NM Viewer is same as Fusion viewer and you will see MIPS and all three orthogonal slice and perf and vent are linked.

3. For HIDA, GI bleed and brain death studies the dynamic display is available on the PACS I-site.

If you go to Grady over the weekend bring your laptop with you so you have the syntermed software available in case you get called to read a EUH cardiac case while at Grady.
If at EUH, a Grady workstation is in the main NM reading room. Another workstation is in the abdominal reading room.

**Accessing EUH or EUHM On Call:**

You will type up your EUH and EUHM reports on Radnet via VDT. [https://www.emoryhealthcare.org/i-am/vdt-VDI.html](https://www.emoryhealthcare.org/i-am/vdt-VDI.html) and log in with your n-number.

You will see this page:
Click on the Radiology Imaging Applications folder, and then choose the **Imaging Interpretation Worklist** (this will open RadNet).

1. When you are in RadNet highlight the patients name then click on the create/edit report icon on the top left hand side of the screen.
2. Assign to your attending see image below and then click on the appropriate template and click modify (on the right hand side of the screen). See below images for reference.
Nuclear Cardiology/Emory Cardiac Toolbox Tutorial

David Cooke (678-371-0931, c Cooke@emory.edu) is our contact at Emory to upload this to your laptop. It can be done remotely or in person. This will be needed for call. He will provide you with a log-in.

Log-in for the cardiac workstation at EUH is located on a sticker stuck to the bottom of the keyboard of that workstation. It also has a PIN which is occasionally needed if the computer is shut down.

During COVID times, trainees will read in the old chest reading room located in the tunnel and will mostly read remotely with those who are located at home.

Phone numbers:

EUH SPECT: 404-778-4752
EUH PET: 404-778-4748
CDU: 404-712-2908
ED: 404-712-7100 or 7109

After a green dot appears next to the patient, you can launch the study (means all files have arrived). In order to launch a study, click on the patient and click launch at the bottom of the dialogue box.

The “slices” will automatically show after a patient is launched.
If parameters need to be adjusted, click on params

Other tabs are relatively self-explanatory. The polar maps/SSS is the updated form of Extent/mass. Keep in mind that these are only as good as what has been selected as the heart during processing. Assessing the DICOM SC tab will let you see if the PET/CT or SPECT/CT fusion is adequate or creating artifacts. Function shows the EF and estimated cavity size, etc.

If a **myocardial blood flow** analysis is needed, call the cardiac PET technologists, number above. This data is only run on an as needed basis. Normal is > 2.0, abnormal is < 1.5. Please take note of the QC parameters for MBF: if you see all greens on the page, it means no QC issues were identified, however if you see yellow or red, it means this might not be trusted. Take care with reporting if QC errors are seen.

**Coronary artery calcium scoring** is done with the syngo.via single sign on icon on the desktop. Calcium scoring is not performed on call (due to camera differences/no scoring software). It is also not performed on patients with chronic kidney disease. To launch a patient, select the patient and right click and select CT CaScoring – this will launch the scoring program if there is a calcium score to assess and if not will launch the CT which we need to look at for incidental findings. To score, click on the small squares with the colored abbreviations of arteries (LM, LAD, etc). Then click or make a circle with the mouse (with left button pushed while circling) the artery you are analyzing.

Make sure to report the score (last column in the table below the scoring window) and not the Equiv. Mass/mg number which is not the Agaston score.
After clicking MM reading on the left column this launches, double click the quadrant with the CT:
Double clicking the CT makes it larger as below. Use the function keys – F5 (soft tissue), F6 (lung), F7 (bone), F8 (narrow window better for liver/brain) – for changing the CT window/level. CT can also be looked at on PACS.

To get back to the list of patients you can close the current patient (clicking the checkmark or pause button on the left-hand column saves your work) or click the person with the magnifying glass next to it.
Make sure you’re using the NM templates (in the template selection in PowerScribe, all NM templates lead with NM if you search all templates); some other cardiac templates are in the system that are used by cardiology.

For the end of the template and risk of death in next year, it is based on the below:

Noninvasive cardiovascular risk stratification (reference is in the template)

<table>
<thead>
<tr>
<th>HIGH RISK (&gt;3% ANNUAL RISK OF DEATH OR MI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Severe resting LV dysfunction (LVEF &lt;35%) not explained by noncoronary causes</td>
</tr>
<tr>
<td>• Resting perfusion abnormalities &gt; 10% of the myocardium in patients without prior history or evidence of MI</td>
</tr>
<tr>
<td>• Severe stress induced LV dysfunction (peak exercise LVEF &lt;45% or &gt;10% drop in LVEF at stress)</td>
</tr>
<tr>
<td>• Stress-induced perfusion abnormalities &gt;10% of the myocardium or stress segmental scores indicating multiple vascular territories with abnormalities</td>
</tr>
<tr>
<td>• Stress-induced LV dilatation</td>
</tr>
<tr>
<td>• Inducible wall motion abnormality (&gt;2 segments or 2 coronary beds)</td>
</tr>
<tr>
<td>• CAC score &gt;400 Agaston units</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>INTERMEDIATE (1-3% ANNUAL RISK OF DEATH OR MI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Mild/moderate resting LV dysfunction (LVEF 35-49%) not explained by noncoronary causes</td>
</tr>
<tr>
<td>• Resting perfusion abnormalities in 5% to 9.9% of the myocardium in patients without a history of or prior evidence of MI</td>
</tr>
<tr>
<td>• Stress-induced perfusion abnormalities 5% to 9.9% of the myocardium or stress segmental scores indicating 1 vascular territory with abnormalities</td>
</tr>
<tr>
<td>• Small wall motion abnormality involving 1-2 segments and only in 1 coronary bed</td>
</tr>
<tr>
<td>• CAC score 100-399 Agaston units</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>LOW RISK (&lt;1% ANNUAL RISK OF DEATH OR MI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Normal or small myocardial perfusion defect at rest or with stress &lt;5% of the myocardium</td>
</tr>
<tr>
<td>• Normal stress or no change of limited resting wall motion abnormalities during stress</td>
</tr>
<tr>
<td>• CAC score &lt;100 Agaston units</td>
</tr>
</tbody>
</table>
NM CRITICAL RESULTS:
Please note that critical results must be **reported WITHIN 30 MINUTES OF OBSERVING A CRITICAL FINDING**. **Direct verbal communication** to a physician is preferred, however if you are having trouble reaching a physician during the time frame, reach out to someone else in the care team including a nurse. Please **record the name of the person you discuss the result with and record the date & time.**

The following items are “Critical Results”

- High Probability V/Q Scan
- Complete airway obstruction on V/Q (no ventilation of one of the lungs)
- Positive GI bleeding study
- Significant ischemia
- Abnormal HIDA scan – either acute cholecystitis or bile leak
- Exam consistent with brain death
Reading Remotely for Grady
Log on to https://citrixnet7.gmh.edu

Follow the prompts for DUO mobile

Once logged in, click Desktops

Click Win10 PACS_PowerScribe and select open. (PLEASE NOTE THAT GRADY WILL SOON BE TRANSITIONING TO SECTRA DESKTOP). This launches the remote desktop as shown below.
Once launched, you should see the desktop below:
Click MIM Shortcut

The screen below should pop up:
Accept the end user agreement

Log in with your Grady ID
The MIM screen should pop up:

Type patient’s name and select appropriate workflow. Samples shown below.

Launch study and start reading. Dictate on Powerscribe as with general studies.
Screening On Call Orders

V/Q SCAN or Q SCAN

History/indication
Chest radiograph results
Best if done within 24 hours, but if doesn’t change interpretation, older or no exam is ok.
Letting the team know that if they don’t have one, we may ask for it later (which may delay interpretation) is ok.

Can the patient lie down flat for an injection?
(recall consequence of relatively lower activity in the upper lung zones)
(Only needs to be supine for a couple of minutes, but best for technologist if they are supine for all of it)

Can the patient follow commands (venting & getting good images will be difficult if they can’t)

Does the patient have known pulmonary hypertension or right-to-left shunt?
We will give half the number of particles for these patients: PHTN patients have a limited pulmonary vascular reserve and we would like to limit clotting in the setting of a R→L shunt since those clots go to end organs (i.e. brain, kidneys, heart, etc.)

D-dimer? (not very specific test, but very high negative predictive value of 99%)

Radiation doses compared for V/Q and CTA:

<table>
<thead>
<tr>
<th>Test</th>
<th>Low-Dose Perfusion ((^{99m}\text{Tc MAA}))</th>
<th>Ventilation/Perfusion ((^{99m}\text{Tc MAA} + {^{133}\text{Xe gas}}))</th>
<th>CT Pulmonary Angiography</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Body Effective Dose (mSv)</td>
<td>0.4</td>
<td>1.9-2.3</td>
<td>5-13</td>
</tr>
</tbody>
</table>

*= ICRP Reports 53 and 80.
AJR 2010;194:881-889

Breast dose is of particular importance in the setting of reproductive age females.

<table>
<thead>
<tr>
<th>Test</th>
<th>Low-Dose Perfusion ((^{99m}\text{Tc MAA}))</th>
<th>Ventilation/Perfusion ((^{99m}\text{Tc MAA} + {^{133}\text{Xe gas}}))</th>
<th>CT Pulmonary Angiography</th>
</tr>
</thead>
<tbody>
<tr>
<td>Breast Dose (mGy)</td>
<td>0.2</td>
<td>0.9-1.4</td>
<td>15-50</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(Use of breast shields may reduce dose by 30-50%)</td>
</tr>
</tbody>
</table>

*= ICRP Reports 53 and 80.
AJR 2010;194:881-889

<table>
<thead>
<tr>
<th>Test</th>
<th>Low-Dose Perfusion ((^{99m}\text{Tc MAA}))</th>
<th>Ventilation/Perfusion ((^{99m}\text{Tc MAA} + {^{133}\text{Xe gas}}))</th>
<th>CT Pulmonary Angiography</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fetal Dose (mGy)</td>
<td>0.1-0.2</td>
<td>0.9</td>
<td>0.02-0.04</td>
</tr>
</tbody>
</table>
But do keep in mind that breasts in the setting of pregnancy are more sensitive to radiation & the radiation dose delivered to the fetus is only negligibly higher.

American Thoracic Society (endorsed by ACOG) recommends the following algorithm to work up PE in pregnancy:

![Diagnostic algorithm for suspected PE in pregnancy.](image)

**Figure 1.** Diagnostic algorithm for suspected PE in pregnancy.


Should have a double arrow between CTPA and VQ.

**Pretest Probability:**

<table>
<thead>
<tr>
<th>Determining the Pretest Probability: Wells Criteria aka Wells Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clinical signs/symptoms of DVT? (+3)</td>
</tr>
<tr>
<td>PE is #1 dx or equally likely (+3)</td>
</tr>
<tr>
<td>Immobilization for 3 days/surgery in last 4 weeks (+1.5)</td>
</tr>
<tr>
<td>HR &gt; 100 (+1.5)</td>
</tr>
<tr>
<td>Previous objectively diagnosed PE or DVT (+1.5)</td>
</tr>
<tr>
<td>Hemoptysis (+1)</td>
</tr>
<tr>
<td>Malignancy with treatment within 6 months, or palliative (+1)</td>
</tr>
</tbody>
</table>

- >6 points: high risk (78.4%)
- 2-6 points: moderate risk (27.8%)
- <2 points: low risk (3.4%)
VQ Interpretation at Emory:

**Clinical Probability of PE:** The actual incidence of PE is highly dependent upon the pretest (clinical) likelihood for the presence of pulmonary embolism (like most other conditions). The utility of the V/Q is optimized when it is interpreted in conjunction with the clinical likelihood for PE. This was well demonstrated in the PIOPED trial.

<table>
<thead>
<tr>
<th></th>
<th>Clinical Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>80-100%</td>
</tr>
<tr>
<td>High</td>
<td>96%</td>
</tr>
<tr>
<td>Intermediate</td>
<td>66%</td>
</tr>
<tr>
<td>Low</td>
<td>40%</td>
</tr>
<tr>
<td>Very low/normal</td>
<td>0%</td>
</tr>
<tr>
<td>Total</td>
<td>68%</td>
</tr>
</tbody>
</table>

**Appropriate Use Criteria in VQ imaging:**

PIOPED V/Q Scan Interpretation Categories and Criteria

High Probability

- At least 2 large (>75% of a segment) mismatched perfusion defects substantially larger than corresponding ventilation or x-ray abnormalities, or without any ventilation or x-ray abnormalities.
- May have greater than or equal to mismatched moderate segmental (>25% and <75% of a segment) plus 1 large mismatched segmental defect, or greater than or equal to 4 mismatched moderate segmental perfusion defects.

Intermediate Probability

- 0.5 to 1.5 mismatched perfusion defects. This may be 1 large plus 1 moderate mismatched perfusion defect or 1 to 3 moderate mismatched segmental perfusion defects.
- Difficult to categorize as high or low probability.
- Absent of perfusion in entire lung or solitary lobar mismatch.
- Solitary moderate or large segmental size triple match in the lower lung zone.

Low Probability

- A single large or moderate size matched segmental defect.
- More than 3 small segmental perfusion defects (<25% of a segment) with a normal chest x-ray.
- Probable PE mimic (mass, or other chest x-ray lesions causing mismatches).
- Moderate-sized pleural effusion (larger than the costophrenic angle but less than one third of the pleural cavity) with no other perfusion defect in either lung.
- Marked heterogeneous perfusion.

Very Low Probability

- Nonsegmental lesion (i.e., prominent hilum, cardiomegaly, elevated diaphragm, linear atelectasis, costophrenic angle effusion with no other perfusion defect in either lung).
- Perfusion defect smaller the chest x-ray lesion.
- 1 to 3 small subsegmental perfusion defects.
- Solitary triple matched defect in the mid or upper lung zones confined to a single segment.
- Stripe sign present around the perfusion defect.
- Pleural effusion at least one third of the pleural cavity with no other perfusion defect in either lung.

Normal

- No perfusion defects present.
- Perfusion exactly outlines the shape of the lungs as seen on chest x-ray (hilar and aortic impressions may be seen, or chest x-ray or ventilation study may be abnormal, i.e., scoliosis).
Procedure Guideline:

http://interactive.snm.org/docs/Lung_Scintigraphy_V4_Final.pdf

HEPATOBILIARY SCINTIGRAPHY:

Questions to ask:
Is this done for cholecystitis or bile leak (look to see if the patient has their gallbladder or a recent operative report).
Duration of NPO or when was the last meal?
   Needs to be NPO for at least 4 hours
   If NPO for greater than 24 hours, then CCK IV needs to be given prior to HIDA injection
Have they had morphine (or other narcotics)?
   This is the most common cause of delayed biliary to bowel transit.
   Needs to be at least 24 hours ago if planning to do functional GBEF evaluation.
Ultrasound findings
Bilirubin (can be done up to a bilirubin level of 21)
   If bilirubin is elevated, need delayed image for up to 24 hours post-injection of the tracer
Don’t give CCK to a pregnant woman (may induce premature labor/spontaneous abortion)

Interpretation:
Clearance of activity from the blood pool
   (delayed, indicates impaired hepatocellular function; may need to carry out imaging for 24h)
Activity in Gallbladder = patent cystic duct
   (if not present within 4h, or following morphine = acute cholecystitis)
Activity in Small bowel = patent common bile duct
   (if not present within 12h and no narcotics = CBD obstruction)

If functional gallbladder study performed, GBEF should be >/= to 38%.
Based on consensus guidelines: http://www.ncbi.nlm.nih.gov/pubmed/22157031
Procedure Guideline:
http://interactive.snm.org/docs/Hepatobiliary_Scintigraphy_V4.0b.pdf
Appropriate Use Criteria in hepatobiliary imaging:

TAGGED RBC/GI BLEEDING SCINTIGRAPHY:

Are they actively bleeding?
What color is the blood?
Has a colonoscopy been done? Results?
If rebleeding, can take patient back for up to 24 hours after injection for delayed images.

Remember, your role is to identify active bleeding and report the site of origin.
Send a report promptly after initial imaging, and let technologist know whether delayed imagining is required.

Look at images in cine mode.
Criteria for a positive study:
- Appears suddenly in an area where there was no abnormal activity previously
- Conforms to GI tract lumen
- Changes in intensity over time
- Moves within the lumen, either anterograde or retrograde or both

Review article: [http://jnm.snmjournals.org/content/57/2/252.long](http://jnm.snmjournals.org/content/57/2/252.long)

**RENAL TRANSPLANT STUDIES:**

A rare event on call.
These can be done for emergent renal indications i.e. status-post renal transplant:
- Blood flow; urinoma, etc. Routine ones are not performed.
Timing of surgery is important, so make sure you know when it was performed.
Review of the perfusion images is VERY important.
Common post-operative complications include:
  - Acute tubular necrosis (ATN): Normal perfusion, progressive cortical retention.
  - Transplant rejection: decreased transplant perfusion and function.
  - Urine leak: extravasated activity around the transplant.
If you have additional questions, contact the on call NM attending.

**BRAIN DEATH STUDIES:**

Brain flow (aka Brain death) studies need to be looked at by an attending before reporting results whenever they happen. This is a high stakes exam and may involve people waiting for gift of life/tissue donation.

Procedure Guideline: [http://interactive.snm.org/docs/Brain_Death_Scintigraphy_V2.0_Final_Draft_for_Approval.pdf](http://interactive.snm.org/docs/Brain_Death_Scintigraphy_V2.0_Final_Draft_for_Approval.pdf)
Thyroid Information

I-123 Uptake and Scan for benign thyroid disease

Patients do NOT need a pregnancy test prior to this exam. Their statement that they are not pregnant is sufficient. If they are pregnant, they should not have the study done. If they are pregnant and they don't know it, the fetus does not have a functioning thyroid at this stage. The amount of radiation is small, unlikely to cause a problem and has a short half-life. There are no radiation restrictions. They should be off of anti-thyroid medications, MVI, and iodine-containing meds. They should have an empty stomach for at least 2 hours before the administration of the dose (capsule(s)) and nothing to eat or drink for 2 hours afterwards. They return at 6 hours for uptake and scan and at 24 hours for a second uptake value.

Procedure Guidelines:
http://interactive.snm.org/docs/Thyroid%20Uptake%20Measure%20v3%200.pdf
http://interactive.snm.org/docs/Thyroid_Scintigraphy_V3.pdf

I-123 total body scan/metastatic survey for thyroid carcinoma

Withdrawal

Patients should be off of thyroid hormone with an elevated TSH level of at least >/= 30 ulU/mL.

An iodine restricted diet (visit www.thyca.org for recipes, etc.) is encouraged to improve the sensitivity of the scan. This is often given to the patient by the endocrinologist, the referring physician. They should remain on this diet until finished with all nuclear medicine procedures (including possible high dose therapy).

Thyrogen®

Patients will receive Thyrogen® (synthetic TSH) injections on day 1 and day 2 to raise their TSH levels. Dosing of I-123 occurs on the third day and imaging occurs 24-hours later. Iodine restricted diet is also encouraged to improve the sensitivity of the scan. Once again, the patient should remain on this diet until finished with all nuclear medicine procedures (including possible high dose therapy).

Procedure Guideline:
http://interactive.snm.org/docs/Scintigraphy%20for%20Differentiated%20Thyroid%20Cancer%20V3%200%20(9-25-06).pdf

I-131 total body scan/metastatic survey for thyroid carcinoma

Similar principle to I-123, but as I-131 also has therapeutic radiation, instructions for the patient are needed, as is a pregnancy test in relevant patients. Generally performed for dosimetry or for follow-up at Emory.
I-131 Therapy ("usually high dose"-for thyroid cancer)
These are not usually ordered until we have seen the results of the total body scan (although some therapies are ordered without a scan). Our therapeutic doses are adjusted based on patient history, pathology, risk and what is shown on the scan. If there is extensive disease, proper dosimetry calculations are needed for sensitive organs like the lungs (to prevent such things as radiation induced fibrosis).

Patients and their living situations are evaluated by us to determine if they are suitable to go home after therapy. These therapeutic doses are high enough so that they will need to be isolated. This is usually for only two days (but depends on the therapeutic dose activity). In most cases they can go home after the treatment. Review NRC Part 35. [http://www.nrc.gov/reading-rm/doc-collections/cfr/part035/](http://www.nrc.gov/reading-rm/doc-collections/cfr/part035/) A pregnancy test is required prior to therapy.

All patients get a prescription from us for Zofran to be taken prior to the treatment and a few additional doses to be taken if needed for radiation induced nausea/gastroenteritis.

We call (or visit daily if hospitalized) patients at least once a day after their treatment until we release them from radiation precautions.

A scan is performed approximately 7 days after the therapy (multiple protocols in the literature) to pick up any metastatic disease that might have been missed on the lower dose pre-therapy whole body survey.

When all is completed, we instruct the patients they can start/restart their Synthroid and go off the low-iodine diet 2 days post-therapy.

Explain to the patient about traveling as well. They will receive a “get out of jail free card” notifying law enforcement that they have been recently treated with a radiopharmaceutical that may trigger a radiation monitoring device.

I-131 Therapy ("low dose” for hyperthyroidism: Graves’ disease, toxic multinodular goiter, and hyperfunctioning nodule)
We like to have a recent thyroid uptake and scan. We accept scans from other institutions (but would like to see the pictures as sometimes they are incorrectly interpreted). Preferably they should be from within the past 3 months. If greater than 6 months, or if the patient has been on anti-thyroid medication, a repeat uptake is needed; often this is performed the same day as treatment. A pregnancy test is required prior to therapy. Patients can go home after this therapy. They are given written radiation safety precautions.

The main side-effect is a sore throat. This is self-limiting and begins 2-3 days after the dose and may last for a week or so. Sore throat lozenges or hard candy is the best way to manage it. If they have a fever, it is an infectious etiology, not from the radiation. Nausea is not usually a problem.

Patients are always told to contact us if they have any questions or problems. Explain to the patient about traveling as well. They will receive a “get out of jail free card” notifying law enforcement that they have been recently treated with a radiopharmaceutical that may trigger a radiation monitoring device.
For more information, visit for a thyroid module:  
http://www.stritch.luc.edu/lumen/MedEd/softchalkhdht/RAITherapy/  
Many more patient instructions are needed than the ones listed above. Be sure to pay close attention when you’re involved in your I-131 therapies.
ONCOLOGIC IMAGING WITH $^{18}$F FDG PET AND PET/CT:

The first thing to know is that things that are “hot” on PET are not always malignancy. Other hypermetabolic lesions can be suggested by the patient’s history (which is remarkably important in the setting of imaging with F-18 FDG). Do your best to find out about these things:

1. Know the patient’s histology, date of initial diagnosis/recurrence
2. Prior XRT & XRT field(s)
   a. And what kind of radiotherapy (SBRT can be + for years)
3. Prior chemotherapy (especially immunotherapy)
4. Recent surgery(ies)
5. Recent exercise
   a. Should be held for 24h prior to PET
6. Chewing gum
7. Was the patient cold/shivering leading up to the exam
8. Trauma: Bumps/bruises/fractures
9. Infections
10. Inflammatory conditions
11. Recent immunizations, etc.
12. Know the patient’s staging based on the most up-to-date staging algorithms:
13. Know how the above situations may impact the appearance
14. Know which tumors can be falsely negative with FDG.

APPROACH TO INTERPRETATION WITH FDG:

Overview
When interpreting PET images, one must take into consideration a number of issues. This is particularly true of imaging with F-18 fluorodeoxyglucose (FDG), which will be the main focus of this chapter on PET interpretation. The following topics will be discussed and clinical pearls will be offered to assist in the correct interpretation.

- Biodistribution and mechanisms of localization
- Patient history
- Patient preparation
- Tumor biology
- Standardized uptake values
- Image viewing and interpretation
- Anatomic imaging complements physiologic imaging
Metabolic imaging with F-18 FDG localizes to tissues by metabolic trapping. The structure of FDG is different from glucose, enabling it to build up in areas of high metabolism, making it very useful for imaging of most tumors. F-18 FDG is localized in the gray matter of the brain, extraocular muscles, tonsils, salivary glands, blood pool, nipples of males and females, liver, spleen, and testes. Variable activity is also noted in the larynx, tongue, hilar regions, glandular tissue of the breast, bowel, uterus and ovaries of premenopausal females (depending on the phase of the menstrual cycle), and areas of muscular activation. The tracer is excreted by functioning kidneys; mild cortical activity is often seen with variable intense activity in the renal collecting systems and ureters (normal distribution is noted to the below, to the left; normal pediatric biodistribution is in the center). The urinary bladder contains the excreted F-18 FDG; the patient should void prior to imaging to reduce artifact in this area. In children, physiological thymic and epiphyseal plate activity is common. Lactating breast will also accumulate F-18 FDG (as seen below, to the right); however, very little is excreted into the breast milk. Babies receive more radiation dose from the close contact with the mother rather than the ingested milk. Expressing milk and having someone else feed the baby is preferable following a F-18 FDG PET scan in a lactating woman. The US Nuclear Regulatory Commission does not require expressed breast milk to be withheld from the infant; however, many institutions choose to recommend against using the expressed breast milk for 6-24 hours. It is recommended that contact with young children be avoided for ~12 hours following PET imaging.
**Patient History**

PET interpretation is optimized when clinicians ask a specific clinical question of the PET scan and provide adequate history. This is particularly true when imaging with F-18 FDG where benign or physiologic uptake can be related to medical intervention or care for chronic medical problems like diabetes, infection, or injury. Recent therapy can also affect the appearance of the scan, so elucidating this is also important. Often, the accompanying CT or MR imaging can increase specificity by showing the anatomic appearance of the process responsible for the metabolic uptake.

<table>
<thead>
<tr>
<th>Entity</th>
<th>Appearance</th>
<th>Reasoning</th>
<th>Timing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Infection</td>
<td>Localized metabolic activity in region(s) of infection, potential for increased splenic activity</td>
<td>Increased expression of glucose transporters by activated inflammatory cells</td>
<td>Variable; if possible, wait 2-4 weeks following infection, especially if in region of oncologic interest</td>
</tr>
<tr>
<td>Inflammatory process</td>
<td>Localized metabolic activity associated with inflammatory process; anatomic imaging may provide clues to etiology (e.g., atherosclerosis, sarcoidosis)</td>
<td>Increased expression of glucose transporters by activated inflammatory cells</td>
<td>Variable and potentially ongoing; if needed, patient could try trial of steroids prior to oncologic imaging if concern for inflammatory disease vs. neoplasm</td>
</tr>
<tr>
<td>Recent surgical intervention/biopsy</td>
<td>Localized metabolic activity, usually in predictable fashion in association with known intervention</td>
<td>Increased expression of glucose transporters by activated inflammatory cells</td>
<td>Usually improved by 4 weeks post intervention</td>
</tr>
<tr>
<td>Radiation therapy</td>
<td>Geometrically shaped area of activity surrounding region of known malignancy; should have uniform distribution unless residual or recurrent disease</td>
<td>Increased expression of glucose transporters by activated inflammatory cells</td>
<td>Variable; depends on type of radiation therapy; stereotactic body radiotherapy, a.k.a. CyberKnife radiosurgery, can have metabolic activity lasting 2 years post therapy</td>
</tr>
<tr>
<td>Chemotherapy</td>
<td>Prominent bone marrow activity</td>
<td>As bone marrow often challenged by chemotherapy, more resources used by bone marrow to replenish depleted cells</td>
<td>Usually improved by 4 weeks following treatment</td>
</tr>
<tr>
<td>Colony-stimulating factors (e.g., Neupogen, Neulasta)</td>
<td>Prominent bone marrow activity</td>
<td>Stimulates bone marrow to help replenish depleted cells; FDG that localizes to bone marrow takes away from injected dose and can falsely reduce standardized uptake value of other FDG-avid lesions by up to nearly 12%</td>
<td>Usually improved by 20 days to 1 month</td>
</tr>
<tr>
<td>Insulin</td>
<td>Prominent muscular activity</td>
<td>Acts as key that opens door to allowing glucose to enter muscle cells</td>
<td>Wait 4-6 hours before performing scan to allow insulin levels to fall</td>
</tr>
<tr>
<td>Recent food intake</td>
<td>Prominent muscular activity</td>
<td>Oral glucose causes increase in endogenous insulin production</td>
<td>Wait 4-6 hours before performing scan to allow insulin and glucose levels to fall</td>
</tr>
<tr>
<td>High blood glucose</td>
<td>Diffuse nonspecific activity throughout body</td>
<td>Nonradioactive glucose competes with uptake of F-18 FDG</td>
<td>Encourage good glycemic control in diabetics in weeks prior to scan</td>
</tr>
<tr>
<td>Metformin</td>
<td>Characteristic large bowel activity</td>
<td>Uncertain</td>
<td>Discontinue for at least 48 hours prior to scan to reduce large bowel activity</td>
</tr>
</tbody>
</table>
Patient Preparation

Proper patient preparation allows for highest quality imaging, especially when using F-18 FDG. When imaging with this radioactive glucose analog, limiting endogenous sugar is very important. This keeps insulin secretion by the pancreas low, thus preventing F-18 FDG uptake into the muscles. Therefore, a fasting state is required for F-18 FDG PET to keep both endogenous glucose and insulin levels as low as possible. Patients should fast for 4-6 hours. Serum glucose levels measured by finger stick prior to imaging should ideally be below 200 mg/dL. Achieving tighter control can be a problem in some brittle diabetics and can lead to more cancellations, delay in imaging, and potentially delay in care. Failure to fast causes muscular uptake (note the image to the left).

Metformin can cause increased large bowel uptake on F-18 FDG PET (in the image to the right); discontinuing metformin for 48 hours may prevent this. This can be especially important for patients with abdominal or pelvic malignancy. Patients can be encouraged to eat a low-carbohydrate diet the day prior to F-18 FDG PET to keep blood glucose levels as low as possible. Strenuous exercise can also cause increased muscle uptake, so patients should avoid this the day prior to the exam. In addition, caffeine can affect myocardial uptake, and nicotine can enhance brown fat activation; these items should be avoided for 24 hours prior to imaging. Any type of uptake outside of the normal biodistribution (e.g., muscle or bone uptake) limits the amount of F-18 FDG available for tumor uptake, causing decreased sensitivity of PET in detecting tumors. In the setting of diffuse bone uptake due to colony-stimulating factors or high-dose chemotherapy (seen to the right), the uptake of F-18 FDG in tumors can be reduced by as much as 11.5%. This can cause inappropriate interpretation regarding the patient’s response to therapy.

After intravenous injection of F-18 FDG, the patient should rest quietly in a warm room for an hour prior to imaging. The patient should refrain from physical activity and talking during this time to limit muscular uptake of the tracer. Extra blankets should be offered to the patient if they are cold; this can limit shivering, which also causes muscular uptake and can limit the appearance of brown fat. Brown fat activation can also be limited by prescan patient warming maneuvers or administration of a benzodiazepine or β-blocker. (Below are examples of normal brown fat activation.)
Tumor Biology
Not all tumor types are F-18 FDG-avid, and PET should be used judiciously in these cases to avoid radiation exposure and cost to the patient. In patients with low or no uptake in tumor on F-18 FDG PET, the interpreter should recommend an imaging modality that would better enable accurate staging (e.g., future studies with CECT only). Some tumor features can suggest low F-18 FDG avidity, such as necrosis (although there may be a rim of metabolic activity), mucinous features, tumors smaller than the resolution of the PET scanner (usually < 1.0-1.5 cm), or ground-glass/semisolid pulmonary lesions. Tumor types known to have low or no F-18 FDG avidity include:

- Minimally invasive adenocarcinomas of lung (formerly known as bronchoalveolar carcinoma)
- Signet ring gastric cancer
- Marginal zone lymphomas
- Hepatocellular carcinoma (well differentiated)
- Chronic lymphocytic leukemia/small lymphocytic lymphoma
- Prostate cancer (can be helpful in more advanced disease, often after initial diagnosis)
- Neuroendocrine tumors (better evaluated with dedicated neuroendocrine tracers, but F-18 FDG avidity can be seen in more undifferentiated neuroendocrine tumors)
- Mucinous adenocarcinoma
- Pancreatic carcinoma
- Renal cell carcinoma (isointense to renal parenchyma)
- Primary breast cancer (often due to small size of primary)
- Iodine-avid thyroid cancers
- Carcinoid

Standardized Uptake Values
Standardized uptake value (SUV) is a semiquantitative measurement of uptake in tissue. Many factors affect the SUV, including accuracy of dose calibration, time between injection and imaging (dose to scan time), patient weight (changes are common in oncology patients), motion artifacts, and blood glucose levels. Many interpreting physicians give SUV values, while some prefer to read qualitatively based on visual comparison with blood pool or liver. Some literature, in particular lymphoma staging systems, is prompting F-18 FDG PET readers to give SUV values so that interpretations can be more standardized and more confidently direct clinical decision-making.

Occasionally, the SUV can be much more intense or much less intense than expected. If this occurs, the reader can measure the SUV of the liver or blood pool, which allows for internal consistency for metabolic activity within a particular patient. Generally, the SUV of the normal liver is between 2 and 5; if it is outside of this range, the values entered for SUV calculation during image acquisition can be checked, as they are likely erroneous. SUV values can be significantly decreased with extravasation of F-18 FDG, which can be seen around the injection site on images if included in the field of view.
**Image Viewing and Interpretation**

When viewing and interpreting any imaging study, all images should be viewed. For the most effective and competent analysis of F-18 FDG PET/CT scans, readers are encouraged to become capable readers of PET images instead of simply readers of fused PET/CT images (or CT readers who check if the abnormalities they detect are "hot"). A step-wise search pattern is most efficient and is outlined below.

- **Maximum-intensity projection (MIP) images**: Quick overview of radiotracer biodistribution and abnormal uptake, providing gestalt of complexity of scan; can also quickly diagnose stage IV disease (e.g., bone metastases or brain metastases)
- **Attenuation-corrected (AC) emission images**: Should be primary set of images for interpretation of PET findings; viewing before anatomic imaging provides reader with most information on metabolic findings and allows for high sensitivity, which is often the point of PET scan when compared with anatomic imaging
- **Nonattenuation corrected (NAC) emission images**: Particularly helpful for evaluation of skin and other superficial lesions especially in skin cancer, lymphoma, or breast cancer) and for evaluation of small lung nodules; provide helpful clues to patient motion or indwelling high-density items that may have overcorrected tracer activity (e.g., surgical hardware)
- **Anatomic images**: After reviewing emission images, accompanying CT or MR images can be analyzed and correlated with PET findings; additional anatomic abnormalities can then be correlated with emission images to check for any abnormal tracer localization; avoid reading CT images 1st, then checking to see if abnormalities are "hot," as this backward-reading style most often decreases reader sensitivity and is cumbersome
- **Fused PET/CT images**: Avoid interpreting from fused images alone, which can obscure PET findings

As scintigraphic images come from a patient who is emitting photons isotropically, the axial, coronal, and sagittal planes are easily constructed. The images should be viewed in all planes. Some planes allow for easy access to the spine (sagittal) or areas of respiratory motion (coronals). Many readers find coronal images helpful for lymph nodes of the neck and groin, small pulmonary nodules, and for comparing the usually less intense splenic activity with the liver. When reading an exam, a tracer-avid finding needs to be different in intensity compared to background activity and well demonstrated in all planes. Knowledge of artifacts and pitfalls is paramount.

**Anatomic Imaging Complements Physiologic Imaging**

Many scans may have “discordant” tracer-avid findings, which have no anatomic correlate (see image below). The anatomic appearance can lag behind the changes in physiology. These findings highlight the sensitivity of F-18 FDG PET imaging, which allows a more holistic view of the patient’s disease. Some clinicians may not understand this. The tracer-avid lesions should be described as nonetheless worrisome when there is no anatomic correlate (e.g., this often occurs with bone/muscle metastases on F-18 FDG PET). An exception would be a labeled thrombus as it is injected lodging in the pulmonary vasculature, a common finding that can prompt a search for occult lung nodule on diagnostic quality CT.
APPROACH TO REPORTING FDG PET/CT:

Overview
Writing a useful report is an art. Here are some suggestions for FDG PET imaging from the history to the impression.

1) History
   a. Did you know that the history is a super important part of the report? Not just for your clinicians and other imagers who might look at your history to try to figure something out (since we’re often given very little), but ALSO BECAUSE the hospital billing department uses this to appeal exams that might be denied for some reason. If your history is minimal, they will have a hard time.
   b. “History of”: We should refrain from using the phrase history of in patients with active disease that we’re evaluating. Our society’s coding guru has urged us to stop this practice. This has implications for reimbursement for the hospital.
   c. Reporting prior therapy: Know what the patient received. Equally important is the TIMING! For metabolic imaging, this is absolutely key, especially with ipilimumab/nivolumab type therapy.
      i. Know what the chemo agents do. It will inform potential things we could see on scan that are false positives. We can talk about this further if you wish.

2) CPT information
   a. The coding information in will change based on the field of view and based on if this is an initial exam (for each malignancy if the patient has more than 1) or a follow-up exam.
i. 78814 (limited area) – for this one I’ll only have relevant sections depending on what is scanned
ii. 78815 (torso) – our standard view: eyes-thighs
iii. 78816 (whole body) – for this one I will add change the reporting to add an extremities section and change the musculoskeletal section to skeleton only.
iv. PI (“initial treatment strategy”)
v. PS (“subsequent treatment strategy”)

3) Comparison imaging
   a. Be specific
      i. “Prior nuclear medicine exams for comparison: date1, date2” doesn’t cut it. What kind of NM exam(s)? List relevant types of NM exams (i.e. bone scan or maybe a sestamibi based exam, etc.) that you might compare to with the PET you’re reading.
      ii. Saying PET or PET/CT also doesn’t cut it. We have more than one PET radiopharmaceutical.
      iii. List all exams (sometimes may be difficult, but could do date1, date2, date3, and others dating back to date23). Sometimes it’s important to go back to the original to see if it was a site of disease from the get-go. I know it takes time, but the clinician who requested the exam would appreciate your thoroughness…as would the patient.
      iv. Don’t forget to list non-NM based images for comparison of the localization CT

1. Example comparison section:


4) Delete what doesn’t make sense from the template
   a. It’s probably fair to say that this makes people want to beat their head against something. Please READ your report. I understand there will be the potential for mistakes (which everyone unfortunately makes from time to time), but please make an effort.
      i. A couple examples from resident reports:
         1. “No FDG avid lesions in the visualized brain” – we actually saw the whole brain in this guy with a whole body scan. We should delete the word visualized.
         2. “The neck shows normal metabolic activity...” and then a couple sentences later “Redemonstration of a lesion...” – Delete the part where it says the neck is fine...this can be dangerous for the clinician who is only skimming this part and read that first sentence, lost interest and skipped to the chest.

5) Choose your words carefully. Make sure the words you’re using are necessary to get to your point. Don’t put in extra words that aren’t needed. My personal preference is for complete sentences; to me this is less confusing compared to the fragments which are often used in imaging reports.

6) Order of reporting. The way to report a PET/CT that makes the most sense to me is to talk about the real disease stuff that is tracer-avid, then the possibly fake tracer-avid stuff and then finally incidental CT findings in each section. I usually start with what I think is the most important tracer-avid finding or the primary lesion and then go from there. I’m sure there are other styles, but this is what makes the most sense to me.
Recall the **Image Viewing and Interpretation** section from above.

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- **Fused PET/CT images**: Avoid interpreting from fused images alone, which can make some findings less or more prominent.

7) **Make sure the next reader can find what you’re talking about.** *ADD IMAGE NUMBERS.* You should do this for every SUV you take and every measured dimension.

8) **Don’t write a paragraph/book for the impression.** Please organize it into points (most important is #1, then the least important thing is in the last point).

9) Other minor points:
   a. When the patient has a chest port, please note where it begins and ends.
   b. Many prefer not to use abbreviations (e.g. SVC), with the exception of SUV and other units (mCi, cm).
IMAGING GENTLY & WISELY

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http://www.imagegently.org

http://imagewisely.org
## REVIEW OF SELECTED NUCLEAR MEDICINE STUDIES:

<table>
<thead>
<tr>
<th>Study</th>
<th>keV</th>
<th>T1/2</th>
<th>Mechanism of localization/Normal distributions</th>
<th>Usual dosage &amp; other considerations</th>
<th>Indication and other information</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Nuclear Cystogram</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tc99m Sulfur colloid</td>
<td>140</td>
<td>6hrs</td>
<td>Compartmental localization</td>
<td>Injectable 0.5–1 mCi Fill to capacity (age+2) x 30 = mL or as tolerated</td>
<td>VUR 50–200x less radiation (usually done after anatomic/radiographic evaluation under fluoroscopy)</td>
</tr>
<tr>
<td><strong>Dynamic renal imaging</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tc99m DTPA</td>
<td>140</td>
<td>6hrs</td>
<td>Glomerular filtration</td>
<td>Dose: 15 mCi</td>
<td>Functional evaluation prior to surgery</td>
</tr>
<tr>
<td>Tc99m MAG3</td>
<td>140</td>
<td>6hrs</td>
<td>Mostly tubular secretion - less background activity compared to DTPA</td>
<td>Dose: 5–7 mCi Image flow &amp; function dynamically, post void Acquired posteriorly for native kidneys, anteriorly for transplant</td>
<td>Lasix to exclude obstruction; dosing depends on Cr</td>
</tr>
<tr>
<td><strong>Renal cortical imaging</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Tc99m DMSA or Tc99m glucoheptonate</td>
<td>140</td>
<td>6hrs</td>
<td>Cortical binding</td>
<td>Dose: 5 mCi Image@2hrs</td>
<td>Pyelonephritis, renal scarring, determination of column of Bertin</td>
</tr>
<tr>
<td><strong>Renal arterial stenosis</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tc99m MAG3</td>
<td>140</td>
<td>6hrs</td>
<td>Mostly tubular secretion</td>
<td>Dose: 5–11 mCi 1. hydrate 2. give ACE inhibitor 15 min before (Vasotec 40 mg or Captopril 25 mg or 50 mg depending on weight) 3. monitor BP 4. if abnl, repeat w/o ACE inhibitor</td>
<td>Renovascular hypertension</td>
</tr>
<tr>
<td><strong>Testicular torsion</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tc99m pertechnetate</td>
<td>140</td>
<td>6hrs</td>
<td>Blood flow and blood pool</td>
<td>Dose: 10 mCi Peds: 250 mCi/kg *give K perchlorate before to block thyroid - obtain immed flow then tissue phase images</td>
<td>Testicular pain; must know side of pain  Salvageable if &lt;4hrs. Nonsalvageable if &gt;24 hrs  Ring sign – missed torsion vs abscess.</td>
</tr>
<tr>
<td>Hepatobiliary Tc99m membrifenin (Choletec) OR Tc99m disofenin (DISIDA)</td>
<td>140</td>
<td>6hrs</td>
<td>Follows pathway of bilirubin, actively transported. Will see more heart/blood pool activity and urinary bladder activity if hepatocellular dysfunction</td>
<td>NPO for &gt;4hrs but &lt;24 hrs. Give sinalcide (CCK) 0.02 mg/kg if NPO &gt;24hrs to clear GB of sludge.</td>
<td>Acute/chronic cholecystitis Biliary dyskinesia Biliary atresia (pretreat with phenobarb for at least 3 days) &lt;30% abnl, &gt;/=30% normal with fatty meal &lt;38% abnl, &gt;/=38% normal with CCK analog</td>
</tr>
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</tr>
<tr>
<td>Tc99m RBC</td>
<td>140</td>
<td>6hrs</td>
<td>Blood pool, heart, liver, spleen, bladder, kidney Know methods of RBC labeling, labeling efficiencies, etc.</td>
<td>Dose: 15-35mCi Hemangioma: 1. Immediate images for 60 secs = blood flow. 2. Delayed @ 1-2 hours GI Bleed (in vitro label): 1. Dynamic images for 60-90 mins 2. Delayed images up to 24hrs ERNA (aka MUGA): 1st pass (RVEF), image 16-30 frames/sec for 30 sec in RAO. Equilibrium gated blood pool for LVEF, LAO best Hemangioma: cold, fills in, hot on delayed. 3cm on planar, 2cm on SPECT GI Bleed: 0.1 - 0.2 mL/sec ERNA: Wall motion and EF more accurate than gated MPI SPECT because of increase in temporal resolution EF= (ED-ES) ÷ (ED-bknd)</td>
<td></td>
</tr>
<tr>
<td>Tc99m sulfur colloid</td>
<td>140</td>
<td>6hrs</td>
<td>Liver&gt;spleen&gt;bone (colloid shift: spleen&gt;liver with liver dz, portal HTN, splenomegaly) Liver/spleen: Dose-8mCi, image @ 20 min GI bleed: dose – 10 mCi, image for 20 mins Reflux: oral dose 300uCi in acidified OJ, Peds dose 1mCi. Image pads at 4 hrs for aspiration Gastric emptying: 0.5-1 mCi with eggs, toast, and water. Image at 0, 1, 2, and 4 hours., anterior &amp; posterior</td>
<td>1. liver mass (hemangioma gets combo with RBC scan) 2. splenosis/trauma 3. Budd-Chiari 4. GI bleed (must be active) 5. GE reflux 6. VUR (as above) 7. Gastric emptying: normal solid is &lt;10% remaining at 4 hours</td>
<td></td>
</tr>
<tr>
<td>Procedure</td>
<td>DMO</td>
<td>Waiting Time</td>
<td>Regions of Interest</td>
<td>Dose</td>
<td>Imaging Schedule</td>
</tr>
<tr>
<td>----------------------------</td>
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</tr>
<tr>
<td>Tc99m pertechnetate</td>
<td>140</td>
<td>6hrs</td>
<td>Gastric mucosa, salivary glands, kidneys/bladder, thyroid, choroid plexus</td>
<td>5-10mCi</td>
<td>Image every 5mins for 60mins. Before study, may give: Glucagon slows SB, Pentagastrin inc. mucosal uptake, Cimetidine to dec. tracer release to bowel</td>
</tr>
<tr>
<td>Bone scan</td>
<td>140</td>
<td>6hrs</td>
<td>Bone, kidneys, bladder, soft tissue. Increased uptake with increased osteoblast activity (this is why sclerotic lesions are seen best).</td>
<td>20mCi</td>
<td>Image @ 2-4 hrs 3 phase: dynamic is 2-5 sec images for 60 secs, blood pool is static images for 5 mins.</td>
</tr>
<tr>
<td>Cardiac perfusion</td>
<td>140</td>
<td>6hrs</td>
<td>Passive localization to mitochondria; electrostatically trapped in proportion to myocardial blood flow. No redistribution.</td>
<td>1 day SPECT</td>
<td>Rest: 8-10mCi, image for 30 mins Stress: 20-30mCi at peak exercise, image at 15-30 mins. Need at least 3x increased dose on stress images.</td>
</tr>
<tr>
<td>Thallium-201 chloride</td>
<td>69-83, 135, 167</td>
<td>73hrs</td>
<td>K+ analog. Actively transported via the Na/K pump. Initial activity based on flow. Redistributes to viable myocardium. NL uptake is thyroid &amp; parathyroid, salivary glands, kidneys, muscle (skeletal &amp; heart), liver, bowel, scalp (not brain)</td>
<td>2-3.5mCi</td>
<td>Initial image @ 10 min after stress. Rest/redistribution – 2-4 hrs later. Additional redistribution images can be taken up to 72h.</td>
</tr>
<tr>
<td>Rb-82 chloride</td>
<td>511</td>
<td>75 sec</td>
<td>K+ analog. Actively transported via the Na/K pump. Excellent in larger patients (i.e. BMI &gt;30 or 35), large breasted patients, prior breast reconstruction or augmentation.</td>
<td>40-60 mCi x 2</td>
<td>Imaged immediately after injection given short half-life. Pharmacologic stress is the only stress method.</td>
</tr>
</tbody>
</table>
### Infarct

**Tc99m pyrophosphate**
- **Dose:** 20mCi
- **Image:** @ 3-4 hrs LAO, lateral
- **Bone, binds to Ca2+ in myocardial infarct**
- **6hrs**
- **No uptake in normal heart, greatest uptake in periphery of infarct. Best 24-48hr after infarct, no uptake for first 12 hours**
- **Many false +**

### V/Q scan

- **Tc99m MAA**
  - **Dose:** 3-5mCi (~350k particles), multiple projections
  - **Perfused lung capillaries (capillary blockade)**
- **Ventilated lung (compartmental localization)**
  - **Dose:** 20mCi. Image breath hold (aka single breath), equilibrium, washout in projection best showing perfusion abnormal.
  - **Dose:** 25-30 mCi put in nebulizer (pt ends up with about 1-2 mCi); can get multiple projections

#### Xenon-133
- **Dose:** 3-5 mCi (~350k particles), multiple projections
- **Image:** @ 3-4 hrs LAO, lateral
- **Bone, binds to Ca2+ in myocardial infarct**
- **6hrs**
- **No uptake in normal heart, greatest uptake in periphery of infarct. Best 24-48hr after infarct, no uptake for first 12 hours**
- **Many false +**

### Thyroid imaging

- **I-123**
  - **Dose:** 200-400 uCi PO Image & uptake at 6hrs, uptake at 24hrs
  - **Nodule, uptake (RAIU) (nl = 7-30%)**
  - **Organification – thyroid only**
  - **Mixture of activation and trapping**
- **Tc99m pertechnetate**
  - **Dose:** 10mCi IV Image @ 20 mins
  - **Substernal thyroid tissue**
  - **Grave’s dose: 8-15mCi, re-treatments get 50% more on second dose.**
  - **Hyperfunctioning thyroid nodule:25mCi**
  - **Toxic multinodular goiter:~30 mCi (29.9**

### Therapy and post thyroidectomy

- **I-131**
  - **364 & β-**
  - **Because of higher energy, images have poorer resolution and septal penetration artifacts are seen.**
  - **Salivary, thyroid remnant, stomach, bowel, bladder, (liver post Rx only b/c thyroid**
  - **Grave’s dose: 8-15mCi, re-treatments get 50% more on second dose.**
  - **Hyperfunctioning thyroid nodule:25mCi**
  - **Toxic multinodular goiter:~30 mCi (29.9**
  - **Therapy of hyperthyroidism**
  - **Therapy of differentiated thyroid carcinomas (papillary & follicular)**
  - **Can perform thyroid uptake**
  - **Substernal thyroid tissue**
  - **1 rad/mCi- must be careful if diffuse lung mets, can cause pulmonary fibrosis.**
<table>
<thead>
<tr>
<th>Procedure</th>
<th>Dose</th>
<th>Time</th>
<th>Description</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Hormone metabolism in liver</strong></td>
<td></td>
<td></td>
<td>mCi; doses &gt;30 require additional instructions.</td>
<td>Diagnostic whole body (4 weeks after surgery): 10mCi, image @ 48 hrs, treat if neck uptake &gt;3% or mets.</td>
</tr>
<tr>
<td><strong>Thyroid ablation</strong></td>
<td></td>
<td></td>
<td>Thyroid ablation dose: 100mCi</td>
<td>Pos. nodes: 150mCi, Mets: 200mCi. Inc. thyroglobulin levels may get treated even with neg. scan.</td>
</tr>
<tr>
<td><strong>Parathyroid</strong></td>
<td>140</td>
<td>6hrs</td>
<td>Thyroid &amp; parathyroid, washes out of parathyroid adenoma more slowly. Thyroid &amp; parathyroid Thyroid only.</td>
<td>Dose: 25mCi. Image: 10 mins planar images, 2hrs planar images with SPECT or SPECT/CT.</td>
</tr>
<tr>
<td>Tc99m sestamibi</td>
<td></td>
<td></td>
<td>Hyperfunctioning parathyroid tissue.</td>
<td>(could also show parathyroid carcinoma, or other non-specific tumor in field of view since sestamibi is a non-specific imaging agent).</td>
</tr>
<tr>
<td>Thallium and Tc99m pertechnetate (subtraction imaging)</td>
<td>159</td>
<td>13 hrs</td>
<td>Heart, Mild salivary, stomach, bowel, bladder, liver <em>can block thyroid</em></td>
<td>Dose: 0.5mCi, image at 24hrs (48 &amp; 72 hrs optional).</td>
</tr>
<tr>
<td><strong>Special tumors</strong></td>
<td>173</td>
<td>67hrs</td>
<td>MIBG is catecholamine synthesis substrate, norepinephrine analog.</td>
<td>MIBG images for: 1. neuroblastoma 2. pheochromocytoma 3. carcinoid 4. islet cell</td>
</tr>
<tr>
<td>I-123 MIBG</td>
<td></td>
<td></td>
<td>MIBG images for: 1. neuroblastoma 2. pheochromocytoma 3. carcinoid 4. islet cell</td>
<td>OctreoScan for: 1. neuroendocrine tumors a. gastrinoma b. carcinoid c. glucagonoma d. medullary thyroid ca e. pheochromocytoma f. neuroblastoma 2. small cell lung, lymphoma, breast 3. astrocytoma, meningioma, thymoma</td>
</tr>
<tr>
<td>In-111 OctreoScan</td>
<td>247</td>
<td></td>
<td>KIDNEYS, spleen&gt;liver, thyroid, GB, bowel Photon poor images</td>
<td>Dose: 10mCi.</td>
</tr>
<tr>
<td><strong>Lymphoscintigraphy</strong></td>
<td>Tc99m sulfur colloid</td>
<td>140</td>
<td>6hrs</td>
<td>Small particles (3-12nm)</td>
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<tr>
<th><strong>Infection</strong></th>
<th>Gallium (Ga-67)</th>
<th>93, 184, 300, 393</th>
<th>78 hrs</th>
<th>Liver&gt;spleen, BM, bone, salivary, *lacrimal, nasal, colon, breast (if lactating)</th>
<th>Uptake secondary to vascular perm, bacterial uptake, and binding to lactoferrin of neutrophil</th>
<th>Infxn dose: 5mCi, image at 48 hrs (72 hr delay to separate from bowel, can use bowel prep)</th>
<th>Tumor dose: 10mCi, image at 72 hrs</th>
<th>Abscess, lung granulomatous disease (TB, histo, fungal, sarcoïd), PCP, IPF, CMV, hypersensitivity pneumonitis, pneumoconioses, pneumonia, lung drug toxicity, Lymphoma, Lung cancer, Liver cancer(HCC), melanoma, sarcoma</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>In-111 WBC</strong></td>
<td>173, 247</td>
<td>67 hrs</td>
<td>Spleen&gt;liver, BM No bowel uptake, sharper images. If lung uptake or liver&gt;spleen, suspect damaged WBC. If inc blood pool, suspect RBC label. Binds mixed leukocytes.</td>
<td>Labeling takes 2 hrs and WBC &gt;2500 1. draw 50cc blood 2. isolate leukocytes 3. label with 0.5mCi In-111 4. Re-inject 5. image@18-24hrs</td>
<td>Abscess, splenosis, IBD, cellulitis, pneumonitis, peritonitis, arthritis</td>
<td></td>
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</tr>
<tr>
<td><strong>Tc99m HMPAO WBC</strong></td>
<td>140</td>
<td>6 hrs</td>
<td>Labeling occurs in plasma, in vitro Dose: 10mCi, image @ 1-2 hrs</td>
<td>Need a WBC count of at least 4 (or 4k; most labs report by the thousands).</td>
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<td><strong>(FDG PET – likely best of the best in most cases of infection)</strong></td>
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<td>We use Tc-99m labeled WBCs for most things, but use Indium for bowel b/c delabeled Tc has bowel activity and prosthesis evaluation (+/- Tc-99m sulfur colloid).</td>
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<td>It should be noted that labeled leukocyte imaging can be <strong>falsely negative</strong> in the setting of vertebral osteomyelitis (3-phase/Ga-67 is better).</td>
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<tr>
<td><strong>Brain death</strong></td>
<td>140</td>
<td>6 hrs</td>
<td>Dose: 20mCi</td>
<td>Brain death – flow in CCA to skull base only, no flow intracranial arteries or major venous sinuses, hot nose secondary to ECA flow</td>
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<tr>
<td><strong>Tc99m HMPAO</strong></td>
<td></td>
<td></td>
<td>Dynamic images for flow, then image @ 10-15 mins to see cortical activity. Absent cortical activity with this agent = brain death</td>
<td>ECD &amp; HMPAO can also be used to identify seizures (best ictally) and dementias (but F-18 FDG is usually done for better resolution)</td>
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<tr>
<td><strong>Tc99m ECD</strong></td>
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<td></td>
<td>25 mCi image immediately for dynamic</td>
<td>This method of imaging is less sensitive and requires a bit more experience for interpretation. Usually reserved for when there is a ECD or HMPAO shortage.</td>
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<tr>
<td><strong>Or Tc-99m pertechnetate</strong></td>
<td>140</td>
<td>6 hrs</td>
<td>See flow only with sagittal sinus activity on delayed images</td>
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<tr>
<th><strong>Cisternography</strong></th>
<th>173, 247</th>
<th>67 hrs</th>
<th>Normally tracer reaches basilar cisterns at 1 hour, convexities at 12 hours, villi in sag sinus at 24 hours, decrease activity at 48 hours. Does not normally enter ventricles b/c physiologic flow is in other direction</th>
<th>Hydrocephalus – NPH v. atrophy (NPH persists in lat vents)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>In-111 DTPA</strong></td>
<td></td>
<td></td>
<td>Dose: 250µCi inject into SA space Image @ 1 hour – spine, 3 hours – skull base</td>
<td>Shunt patency</td>
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<td>CSF leak (+ if pledget to plasma ratio &gt;2:3:1)</td>
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</tbody>
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<thead>
<tr>
<th><strong>Palliative Bone pain therapies</strong></th>
<th>103γ &amp; B-</th>
<th>46 hrs</th>
<th>Incorporated to hydroxyapatite matrix</th>
<th>Refractory bone mets, failing all other treatments</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Samarium-153</strong> (Sm-153)</td>
<td></td>
<td></td>
<td>Dosing: 1 mCi/kg; administered IV over 1 min</td>
<td>Must have a positive WBBS with Tc99m MDP as it is localized the same way (makes sense that localizes to osteoblastic and not osteolytic lesions)</td>
</tr>
<tr>
<td><strong>Strontium-89</strong> (Sr-89)</td>
<td>B-only</td>
<td>50 d</td>
<td>Dosing 4 mCi for everyone; administered IV over 1 min</td>
<td></td>
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</tbody>
</table>

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<tr>
<th><strong>Ra-223 dichloride</strong></th>
<th>αγ</th>
<th>11.4 days</th>
<th>Similar localization to Sm-153 and Sr-89</th>
<th>Indication is castration-resistant prostate cancer with symptomatic osseous metastatic disease and no known visceral metastatic disease. Visceral disease defined as lymph node &lt;3cm.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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<td></td>
<td><strong>Has survival benefit, not palliative therapy.</strong></td>
</tr>
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</table>

<table>
<thead>
<tr>
<th><strong>Gastric Emptying</strong></th>
<th>140</th>
<th>6hr</th>
<th>Compartmental localization</th>
<th>Normal solid: 10% retained by 4 hours (at least 90% emptying)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Sulfur colloid in eggs with bread and 8 oz water</strong></td>
<td></td>
<td></td>
<td>Dose: 0.5mCi</td>
<td>See consensus guidelines: <a href="http://interactive.snm.org/docs/Guideline%20for%20Adult%20Gastric%20Emptying.pdf">http://interactive.snm.org/docs/Guideline%20for%20Adult%20Gastric%20Emptying.pdf</a></td>
</tr>
<tr>
<td>for solid emptying</td>
<td>Acidified liquid with sulfur colloid or In-111 for liquid</td>
<td>Normal liquid: half-time clearance value is 12-64 minutes. If no emptying, work up patient for gastric outlet obstruction/malignancy</td>
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<tr>
<td><strong>Y-90 microsphere therapy</strong></td>
<td>B-only 64 hr Localized via arterial canalization in concert with IR Dose depends on volume of tissue treated and lung shunt performed with Tc-99m MAA prior to treatment</td>
<td>Differences are present between dosing &amp; technique for the 2 different microsphere types (TheraSphere vs SirSphere). Read about it. Imaging can be performed of this β only radiopharmaceutical via Bremsstrahlung imaging or with the PET scanner.</td>
<td></td>
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<tr>
<td><strong>Y-90 radioimmunotherapy (RIT)</strong></td>
<td>B-only 64 hr Localized by the antibody Dosing depends on type of RIT</td>
<td></td>
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</tr>
<tr>
<td><strong>Lu-177 DOTATATE</strong></td>
<td>B-γ: 6.7 d Binds to somatostatin receptors of well-differentiated neuroendocrine tumors (esp. SSTR2) Complicated dosimetry</td>
<td>Considered “theranostic” agent used in conjunction with Ga-68 DOTATATE for assessment of therapeutic efficacy. Therapy performed in conjunction with amino acid infusion</td>
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<tr>
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<tr>
<td>Carbon-11 choline</td>
<td>PET imaging of patients with suspected prostate cancer recurrence and noninformative bone scintigraphy, CT, or MR</td>
<td>Targets choline kinase; choline, important precursor molecule for cell membrane synthesis, is utilized at high rate in dividing cells</td>
<td>High normal uptake seen in renal cortex, pancreas, liver, salivary glands; variable uptake present in pituitary, bowel, and prostate gland; low-level activity present in cerebral cortex; critical organ is pancreas</td>
<td>Patient well hydrated; usual dose 10-20 mCi (370-740 MBq); as agent is rapidly cleared from bloodstream (t1/2 ~ 1 min); imaging ~ 2 min after injection; patient scanned inferior to superior as agent excreted in urine</td>
</tr>
<tr>
<td>Fluorine-18 florbetapen</td>
<td>PET imaging of brain to estimate β-amyloid neuritic plaque density in adults with cognitive impairment being evaluated for Alzheimer disease (AD) or other causes of cognitive decline</td>
<td>Targets β-amyloid; this agent will bind to amyloid plaques in brain as amyloid is thought to be driven in AD, negative exam effectively excludes this type of dementia</td>
<td>Normal exams demonstrate tracer uptake into white matter in uniform pattern; gray matter uptake is low, particularly in posterior cingulate/precuneus, frontal lobes, lateral temporal lobes, and parietal lobes; critical organ is gallbladder; reader training required prior to interpretation</td>
<td>Typical dose 8 mCi (300 MBq) as slow IV bolus; images acquired 45-130 min after injection, typically performed 15-20 min</td>
</tr>
<tr>
<td>Fluorine-18 florbetapir</td>
<td>PET imaging of brain to estimate β-amyloid neuritic plaque density in adults with cognitive impairment being evaluated for AD or other causes of cognitive decline</td>
<td>Targets β-amyloid; this agent will bind to amyloid plaques in brain as amyloid is thought to be driven in AD, negative exam effectively excludes this type of dementia</td>
<td>Normal exams demonstrate tracer uptake into white matter in uniform pattern; gray matter uptake is low, particularly in posterior cingulate/precuneus, frontal lobes, lateral temporal lobes, and parietal lobes; critical organ is gallbladder; reader training required prior to interpretation</td>
<td>Usual dose 10 mCi (370 MBq) as single IV bolus; 10-min image following uptake of 30-50 min</td>
</tr>
<tr>
<td>Fluorine-18 fluciclovine</td>
<td>PET imaging agent used in men with suspected prostate cancer recurrence based on elevated PSA levels following prior treatment</td>
<td>Targets amino acid metabolism; radiotracer is analog of leucine; localizes into prostate cancer cells via ASCT2 or LAT1 transporters</td>
<td>Highest areas of uptake seen in liver, pancreas, lung, myocardium, and red bone marrow; critical organ is pancreas</td>
<td>Usual dose 10 mCi (370 MBq) via IV bolus; avoid strenuous exercise day prior and fast at least 4 h prior; imaging begins 3-5 min after injection; typical scan 20-30 min, performed inferior to superior to diagnose positive findings; for lesions &gt;1 cm, uptake ≥ bone marrow activity; for lesions &lt;1 cm, focal uptake &gt; blood pool activity</td>
</tr>
<tr>
<td>Fluorine-18 FDG</td>
<td>PET imaging used to assess abnormal glucose metabolism in oncology, assess myocardial hibernation, identify regions of abnormal glucose metabolism associated with foc of epileptic seizures, dementia evaluation; use for cardiac sarcoidosis and infection is considered “off-label”</td>
<td>Localizes in areas of 1 metabolic potential; translocates into cells via GLUT; after phosphorylation by hexokinase, does not continue down metabolic pathway like regular glucose (FDG is ringed structure compared to glucose, which is branched carbohydrate); once phosphorylated, FDG-GP essentially trapped within cell</td>
<td>Normal uptake seen in gray matter, extracranial metabolons, salivary glands, bladder pool, nipples of males and females, liver, spleen, adrenals; variable activity also noted in larynx, tongue, hilum regions, glandular tissue of breast, bowel, uterus, and ovaries of premenopausal woman (depending on phase of menstrual cycle); tracer excreted by functioning kidney; in children, thymic and epiphysial plate activity commonly seen; lactating breast will also accumulate FDG; critical organ is urinary bladder; user training available</td>
<td>Patient well hydrated; usual adult dose 5-10 mCi (185-370 MBq); North American Consensus Guidelines for Administration of Activity in Pediatrics for pediatric patients; oncology: Blood glucose 200 mg/dL or lower prior to injection; fast for minimum of 4 h; insulin avoided; avoid strenuous exercise for 24 h prior to imaging; low-carbohydrate diet day prior to exam; void prior to imaging; hibernating myocardium: Blood glucose manipulated with glucose and insulin to force myocardium to take up FDG; brain imaging: Patient placed in dark/quiet room following administration</td>
</tr>
<tr>
<td>Radiopharmaceutical</td>
<td>Indication</td>
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<td>Biodistribution</td>
<td>Imaging Protocol</td>
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<tr>
<td>Fluorine-18 flutemetamol</td>
<td>PET imaging of brain to estimate β-amyloid neuritic plaque density in adults with cognitive impairment; being evaluated for AD or other causes of cognitive decline</td>
<td>Targets β-amyloid; this agent will bind to amyloid plaques in brain; as amyloid is thought to be driven in AD, negative exam effectively excludes this type of dementia</td>
<td>Normal exams demonstrate tracer uptake into white matter in a uniform pattern; gray matter uptake is low; frontal, lateral temporal, and inferolateral parietal lobes, posterior cingulate, precuneus and striatum are areas of particular diagnostic consideration; the critical organ is the gallbladder; reader training is required prior to interpretation</td>
<td>Usual dose 5 mCi (185 MBq) as single IV bolus; 20-min image after 90-min uptake</td>
</tr>
<tr>
<td>Fluorine-18 sodium fluoride (NaF)</td>
<td>PET bone imaging agent to delineate areas of altered osteogenesis</td>
<td>Extracted from extracellular fluid and incorporated into hydroxyapatite crystals, forming fluorapatite; this occurs more often in areas of increased bony turnover; leading to areas of increased uptake; this agent has improved pharmacokinetics compared to traditional single-photon bone imaging with more rapid clearance of the tracer from the blood stream and a higher target:background ratio (2x higher osseous uptake)</td>
<td>Normal exams demonstrate tracer uptake into the skeleton; excrated activity is seen along the course of the urinary tract in a patient with functioning kidneys; mild soft tissue activity will also be seen; children will have normal epiphyseal plate uptake in symmetric fashion; critical organ is urinary bladder</td>
<td>Patient well hydrated; usual adult dose 9-12 mCi (338-444 MBq); North American Consensus Guidelines for Administered Activity in Pediatrics for pediatric patients; imaging 30-45 min after administration; whole-body images generally performed; imaging 2-5 min per camera bed position; currently available under Nuclear Oncologic PET Registry, but otherwise not widely available</td>
</tr>
<tr>
<td>Gallium-68 dotate</td>
<td>PET imaging of adult and pediatric patients with somatostatin receptor-positive neuroendocrine tumors</td>
<td>Binds to somatostatin receptors with highest affinity for subtype 2 receptors (SSTR-2); mechanism of localization is similar to In-111 pentetreotide; however, sensitivity is greatly improved</td>
<td>Normal uptake is seen in all SSTR-2 expressing organs, including pituitary, thyroid, spleen, adrenal glands, kidneys, pancreas (especially uncinate process), prostate, liver, and salivary glands; no cerebral, cortical, or cardiac uptake; low-level uptake in thymus and lungs; some nonspecific uptake can be seen in tumor types other than somatostatin receptor-positive neuroendocrine tumors (NETs) (i.e., tumors derived from neural crest tissue, thyroid diseases, inflammation, etc.); if unclear etiology histopathologic correlation indicated</td>
<td>Patient well hydrated; dosing based on patient weight: 0.054 mCi/kg (2 MBq/kg) with max dose of 5.4 mCi (200 MBq); patients treated with somatostatin analogs imaged just before next long-acting dose; short-acting analogs held for 24 h; imaging of skull to mid-thigh region 40-90 min after IV dosing</td>
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<tr>
<td>Nitrogen-13 ammonia</td>
<td>PET myocardial perfusion imaging of myocardium under rest or pharmacologic stress conditions to evaluate suspected or existing coronary artery disease</td>
<td>Extracted from blood in proportion to regional myocardial blood flow where it is metabolized to glutamine and retained in myocytes</td>
<td>Normal biodistribution includes brain, liver, skeletal muscles, myocardium, and other organs; critical organ is kidneys; occasionally, apparent decreased perfusion of lateral wall is seen</td>
<td>Usual dose 10-20 mCi (370-740 MBq) as IV bolus; imaging 3 min following administration, acquired for 10-20 min</td>
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<tr>
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<tr>
<td>Rubidium-82 chloride</td>
<td>PET myocardial perfusion imaging of myocardium under rest or pharmacoologic stress conditions to evaluate suspected or existing coronary artery disease</td>
<td>Potassium analog taken up by Na⁺/K⁺ ATPase pump of myocytes, extracted from blood in proportion to regional myocardial blood flow</td>
<td>Biodistribution similar to Tl-201 chloride; critical organ is kidneys</td>
<td>Usual dose 30-60 mCi (1.1-2.220 MBq) from on-site Sr-82/Sr-82 generator; imaging generally performed 60-90 min following IV infusion in patients with limited cardiac output, delayed imaging of 120 s post injection considered; testing of generator system for breakthrough Sr-82 or Sr-85 required</td>
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<tr>
<td>Half-life: 1.25 min</td>
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<tr>
<td>Positron E&lt;sub&gt;max&lt;/sub&gt;: 3.378 MeV</td>
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NORMAL BIODISTRIBUTIONS:

Bone scan

Adult
Pediatric bone scan (note activity at growth plates; changes with age)
V/Q Scan with Xe-133 gas ventilation
V/Q Scan with Tc-99m DTPA aerosol ventilation (GI activity is normal, from swallowed aerosol). This patient also has severe COPD.
Good example of a high probability V/Q Scan

Meckel's scan
A positive Meckel's scan (ectopic gastric mucosa; etiology is failed closure of omphalomesenteric duct)

For reference, normal biodistribution of Tc-99m pertechnetate
Expect to see: salivary glands, thyroid, stomach, choroid plexus; can also see some renal excretion and other bowel activity.
Tc-99m Sulfur colloid
I-123 MIBG

123-I MIBG SCAN 24 HR

ANTERIOR

POSTERIOR

ANTERIOR

POSTERIOR

ANTERIOR

POSTERIOR
In-111 OctreoScan (images usually taken at 24 and 48 hours)
Gallium-67 citrate
In-111 labeled WBCs (recall that bowel/urinary tract activity is abnormal).
Tc99m HMPAO (Ceretec) WBC’s – similar but better resolution & can see bowel activity (this is why we **don’t** use this agent in the setting of abdominal infection evaluation).
Injection in central line (which still contains activity and moves during course of exam; some contamination as well) Better appreciate GI/urinary tract activity.
F-18 FDG PET

The activity within the brain is considered normal since the brain is an obligate glucose user.

Variable low-level & non-focal bowel activity is a normal variant.
Ga-68 DOTATATE (NETSPOT)
(Not normal, but notice intense splenic, renal and liver activity, similar to OctreoScan, but with better resolution). Please refer to table above for normal biodistribution.
F-18 sodium fluoride (NaF) – PET bone scan
Not entirely normal; arthritic changes and compression fracture.
F-18 fluciclovine (Axumin)
Resident Lectures 2020-2021

Nuclear Medicine

Resident Lectures – 7:30 AM:

Please choose topic to discuss 1-2 months in advance and email Dr. Grady with the topic and any relevant reading material you would like the give group ahead of time.

- Friday, 10/23/2020 – Dr. Newallo
- Friday, 11/13/2020 – Dr. Dhingra
- Friday, 12/11/2020 – Dr. Shogbesan
- Friday, 1/15/2021 – Dr. de Macedo Filho

Journal Clubs – 7:30 AM:

Choose a journal article with your assigned attending (not a review article) to discuss the scientific method and findings. Can be in nuclear medicine journals or in other specialties as long as it pertains to our practice. Please send the article to Dr. Grady at least 1 month in advance.

- Tuesday, 9/29/2020 – Dr. Shogbesan with faculty mentor Dr. Muzahir
- Monday, 2/8/2021 – Dr. Dhingra with faculty mentor Dr. Takalkar
- Tuesday, 3/30/2021 – Dr. de Macedo Filho with faculty mentor Dr. Sethi
- Monday, 4/12/2021 – Dr. Newallo with faculty mentor Dr. Hall

Stump the Attending/Missed Case Conference – 7:30 AM:

All residents bring 1 imaging case to show along with discussion of findings, differential diagnosis and patient outcome if missed case. Consider submission to Clinical Nuclear Medicine (or other journal) for interesting image publication. Faculty involved with the case or Dr. Grady can help with submission if desired.

- Tuesday, 10/27/2020
- Friday, 3/5/2021
- Monday, 5/10/2021
- Friday, 6/4/2021
Systemic Quality Improvement – 7:30 AM:

Occurs four times per year. Please identify a topic involving patient safety or quality of care delivery; engage an attending to assist. This should be a relevant and timely topic and may involve another specialty group. Aim is to drive discussion and enhance quality in Nuclear Medicine. Please engage others in our division who may be impacted by the discussion (i.e. nurse navigators in therapy or technologists, etc).

- Friday, 8/28/2020: Dr. Newallo
- Monday 2/1/2021: Dr. Dhingra
- Monday 4/19/2021: Dr. Shogbesan
- Tuesday, 6/8/2021: Dr. de Macedo Filho

Mentors for 2020-2021 Academic Year:

Please meet at least quarterly throughout the year with your mentor.

<table>
<thead>
<tr>
<th>Dr. Dhingra</th>
<th>Dr. Hall</th>
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<tr>
<td>Dr. de Macedo Filho</td>
<td>Dr. Brandon</td>
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<td>Dr. Newallo</td>
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<td>Dr. Shogbesan</td>
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