

Getting Started — A Guide to Year One of Radiology Residency

[3rd Edition]



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RESIDENT & FELLOW
SECTION
AMERICAN COLLEGE OF RADIOLOGY



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The Transition Point: Challenges & Opportunities

Introduction

Developed by current residents and fellows, this guide is intended to help ease the transition from internship into radiology residency. Having recently graduated from medical school and intern year, you have likely garnered an armamentarium of clinical skills and knowledge; however, your training has not prepared you for the specific challenges of becoming a radiologist. From the first day of radiology residency, you will be asked to adopt several roles in your daily work, much of which will seem foreign. In this chapter, we discuss the inherent challenges and opportunities of being a novice radiology resident with specific tips to help you excel in your various new responsibilities.

Advisor

From day one, you will be at the forefront of the department in advising referring clinicians, patients, technologists and others regarding anything within the broad spectrum of radiology. It is impossible and entirely unexpected that you would have expeditiously learned the nuances of the field during your internship; nonetheless, you will still be asked questions for which you do not know the answer. Your best strategy is to prepare methods of accessing the answers to the most common questions quickly by creating cheat sheets, quick links or institutional references for guidance. Below are suggested ways to best prepare for your role as an advisor.

- **Be polite.** Introduce yourself, explain your role and ask how you can assist the caller, clinician or patient. Attempt to answer their question(s) if possible, but if it is not emergent or you are unsure of the answer, ask if you can return their call and take down their name, number, patient information and question. You will interact with a variety of people daily, and you should always be respectful.
- **Quick sheet of important phone numbers.** It can be difficult to find the right person for a particular question in the radiology department; therefore, you should be prepared to provide phone numbers and directions. It may even be easier to personally take people to the appropriate area.
- **Reference for all imaging protocols.** This will help make sure you follow protocol correctly as well as answer clinician and patient questions regarding preparation, timing and radiation. It is also important to have a checklist when checking/reviewing images for technologists as an incorrect protocol can result in a non-diagnostic study.
- **Review imaging indications and parameters for pregnant patients.** Your institution will likely have a policy for imaging pregnant patients. Knowing this policy as well as the radiation risk to the fetus is essential for the counseling of patients and clinicians. Refer to the guidelines by the ACR-SPR in their [Practice Parameter for Imaging Pregnant or Potentially Pregnant Women](#).

- **Review and create a quick reference on contrast reactions, allergies, contraindications and consent requirements.** This is one of the most frequently asked questions and being a radiologist you must be the expert. Refer to chapter 5, Contrast 101 and the [ACR Manual on Contrast Media](#).
- **Review the ACR Appropriateness Criteria.** Useful reference designed to guide radiology ordering practice for specific clinical questions/situations. Refer to [ACR Appropriateness Criteria®](#), [Image Gently®](#) and [Image Wisely®](#) for specifics about appropriate imaging indications, pediatric imaging and radiation safety.
- **Know when to ask your senior residents or an attending.** Don't be afraid to ask someone more experienced if you are unsure of the answer to a question. It is often more important to know what you don't know, than to know what you know.

Interventionalist

Every subspecialty in radiology from nuclear medicine to neuroradiology and fluoroscopy has its own unique procedures, interventions and direct patient interaction. Although you will eventually become an expert in these procedures, quickly coming up to speed with the technique, risks and appropriate counsel of patients and ordering clinicians can be daunting. Experience is paramount — as with all procedures in medicine — but gaining confidence is often difficult. The following is a list of tips to help prepare for radiology procedures:

- **Learn the next day's schedule and review online videos or observe your colleagues.** There are a host of websites, tutorials and papers dedicated to the performance of the various radiological procedures.
- **Review the patient's medical history and imaging.** You are a proceduralist and a clinician, so it is essential that you review the reason for the procedure, past medical history, allergies and relevant medications (e.g., anti-coagulants, sedatives and immunosuppressants) in order to prepare.
- **Courteous and respectful bedside manner.** Obviously, you have probably not developed a relationship with the patient, and yet you are often performing procedures with serious potential risks. It is essential to quickly earn their respect by being honest, courteous and professional.
- **Learn the risks and benefits.** You will be consenting and counseling patients; review the percentages of the potential risks from relevant papers or your institution and think about the applicable benefits to that particular patient.
- **Be accurate and concise in your electronic health record notes.** You will be writing pre-procedure, procedure and consult round notes, and you should act as if you are the patient's primary physician. Avoid copying and pasting from other clinicians' notes and proofread your notes, particularly if you are using EMR templates. Nothing looks worse than careless and inaccurate notes.
- **Know the common questions and answers.** Know how long the pathology usually takes for results, how long a procedure usually takes, and how long to stop anticoagulants or other medications. Ask your seniors, as they likely know the answers to these common questions.

Educator

Imaging is at the forefront of every patient's diagnostic workup and treatment. As the expert, you will be called upon to discuss the images in a variety of situations. Even as a first-year, you may be asked to present the imaging studies at medical or surgical conferences, tumor boards, multidisciplinary groups or resident lectures. The following are some tips to help you as you prepare for these opportunities:

- **Attend as many conferences as you can.** You can learn effective presentation style and design by observing and learning from others.
- **Seek ways to participate in these conferences.** Ask to present a lung cancer patient from a lung cancer screening CT you read, provide a patient update at a tumor board or give an update on new recommendations like the newest BI-RADS®. These are just some examples of ways you can get involved.
- **Create a first-year QI/QA or education case conference.** Examples include a resident exclusive conference to share cases that were missed or great teaching cases.
- **Review your presentation with an attending or fellow.** It's always important to get an outsider perspective to check for mistakes and possible improvements.
- **Collaborate with other specialists to create conferences or joint learning opportunities.** Review interesting cases by discussing the imaging findings, diagnosis, treatment and post-treatment care in order to learn from each other. Alternatively, help your colleagues learn a skill such as ultrasound-guided biopsy or FAST exams and have them teach you something in return.



Be Involved & Take Action

Introduction

Stepping out of the reading room is essential in order to gain experience and establish yourself in the various avenues within radiology. Getting involved is easy as there are numerous opportunities at both the local and national level. In this chapter, we discuss the opportunities available as a first-year resident to get started. The key to being involved is simple: be present. If you show up, introduce yourself and network, you will get the opportunity to be involved.



Leadership

Taking on a leadership role can be as simple as getting involved with your program's education committee or as complex as being elected at the national level to serve in the ACR Resident and Fellow Section. Radiology is at a crossroads with establishing its future role in medicine. In order to train more motivated and well-rounded leaders of the future, the ACR created the [Radiology Leadership Institute](#)® (RLI). The RLI provides a comprehensive catalog of lectures, online courses and webinars to fill in the gaps of the traditional radiology training in areas such as economics, social media, big data, evaluating a job offer, mentoring and much more. In addition to regular online programming, the RLI also offers scholarships for trainees to their annual meeting every fall.

- **Program/Institution:** Volunteer to serve on the education committee, such as a resident expert for electronic health records (e.g., Epic or Cerner), the ACGME resident representative or the IRB committee. Find other opportunities from graduating residents stepping down from positions, your institution website or emails/bulletins and get involved. Ask your chiefs, seniors and program director what opportunities exist for residents to get involved.
- **State/Regional:** Get involved in your state [ACR chapter](#) and find positions or committees that are available for volunteers. Many local chapters have a dedicated RFS section for residents to get involved.
- **National:** Attend the Resident and Fellow Section Annual Leadership Conference at the ACR meeting in May where you will meet with other resident leaders from around the country, be immersed in the key issues in radiology and be a part of the election of residents for the RFS. Many state chapters will sponsor residents to attend. Join [RADPAC](#)® and Radiology Advocacy Network to learn more about government relations in medicine. Apply for an [ACR fellowship](#) in government relations, education, economics or publishing. Similar opportunities exist in many of the other societies listed below. Again, the key to being involved and getting these opportunities is networking and being present. Many radiology organizations have dedicated trainee sections and committees (ACR RFS, Society of Breast Imaging (SBI) RFS, Radiological Society of North

America (RSNA) RFC, Society of Abdominal Radiology (SAR) RFS, and more) that will provide you with many more opportunities to be involved and serve on various committees. Association of University Radiologists (AUR) has an annual ARRALD program that your program director can nominate one resident to attend. Many national conferences also have dedicated programming and social events for trainees, which you should absolutely attend.

- **Social Media:** Another great way to ease into the leadership microcosm is to delve into the spheres of Twitter, Facebook, YouTube, LinkedIn and other online communities. Check out the [ACR RFS Facebook Page](#), follow [@ACRRFS](#) and [#RadRes](#) to find out more about the aforementioned opportunities and the latest news. Radiology has a particularly large and active presence on Twitter and the platform is great for networking.

Make a professional Twitter account and interact with others in radiology. People have even been granted leadership opportunities and experiences via Twitter.

Academics


Approach your co-residents, fellows or attendings with a sincere motivation and interest in a project they are working on or present your novel idea and you will succeed in getting started.

- **Review the previous year's abstracts:** Whether you are submitting to a conference, journal or online exhibit, the best way to ensure you have the highest likelihood of acceptance is by previewing those previously accepted. You can also get a sense of how to word your abstract succinctly and properly.
- **Follow the guidelines:** Read all of the guidelines and make sure you have everything from word limits, structure and deadlines correct. The most common reason a manuscript is rejected is because the journal's guidelines were not followed.
- **Investigate the prices and times:** Most programs cover presentations or conferences to some extent but make sure you know how much, what steps you need to take before submission/acceptance and what you need to submit to get reimbursed. Also, explore whether the conference has a scholarship opportunity or discount opportunity for trainees. Many organizations offer discounts for members and free membership for residents. Make hotel reservations early. Most discount rates organized by conferences will sell out, especially at the most conveniently located hotels. With the exception of RSNA, you can usually cancel your hotel reservation without penalty if your plans change.
- **Look for topics that are always presented that you could add a new element to or have never been presented:** By simply looking at the journal or conference and seeing what has their attention could help you figure out what is the right place for your submission.
- **Develop an IRB application template:** After your first IRB application you will know all of the questions and requirements, and you can create a template to plug in the changes for any future projects.
- **Seek out funding and grants:** Apply for RSNA H&E grants or other scholarships through the various societies or your institution. Many societies have grants and scholarship opportunities dedicated for trainees.

- **Check journals for trainee opportunities:** Many journals have started to create trainee editorial boards, trainee advisory committees and other trainee-focused opportunities. Radiology, AJR and Radiographics all have opportunities for trainees.
- **Check conferences for trainee opportunities:** Conferences may also have opportunities for trainees, like exhibit review. American Roentgen Ray Society and RSNA have an annual “Introduction to Academic Radiology” course that your program director can nominate an R2 for. Society for Skeletal Radiology (SSR) has an “SSR Scholars” program for R1s and R2s interested in MSK radiology.
- **Don’t be discouraged by failure:** Everyone has exhibits, presentations and manuscripts rejected. A single rejection is not a death sentence for a project. Projects can be resubmitted elsewhere and you will find a home for your project. A rejection is not the end, just a nudge in a different direction.

Quality & Safety

Completing a quality improvement project is a residency requirement but knowledge of the process is vital to contributing to your future practice as these projects are part of the Maintenance of Board Certification process.

-  **Complete any required institutional education certificates or processes:** Many institutions will have online courses, retreats or curricula to train their professionals to complete the QI/QA process by their means. Look into any requirements before getting started.
- **Find errors or inefficiencies and seek a solution:** Be cognizant of the processes in place and points that are interruptive, confusing or redundant and find a mentor to help form a task force to improve the process. If something happened that didn’t make sense to you, point it out and ask staff about it. Sometimes a new set of eyes notices something that everyone else has simply accepted.
- **Present your successes and failures:** Submit your project to the institution quality committee, state chapter or national conference. Not only can you share a project which may be universally applicable, you can also get more involved in larger quality projects as you gain a reputation for achieving results. Opportunities to present can vary from a poster at your local institution’s Academic Excellence Day to an oral presentation at a major national meeting. Take advantage of the varied opportunities.

Basic list of societies:

American Board of Radiology theabr.org

American Roentgen Ray Society arrs.org

Association of University Radiologists aur.org

The Radiological Society of North America rsna.org

American Association for Women in Radiology aawr.org

American College of Radiation Oncology acro.org

American Society of Emergency Radiology aser.org

American Society of Head and Neck Radiology ashnr.org

American Society of Neuroradiology asn.org

American Society for Radiation Oncology astro.org

Society of Abdominal Radiology abdominalradiology.org

Society for Advanced Body Imaging advancedbodyimaging.org

Society for the Advancement of Women's Imaging
omicsonline.org/societies/the-society-for-the-advancement-of-women-s-imaging

Society of Breast Imaging sbi-online.org

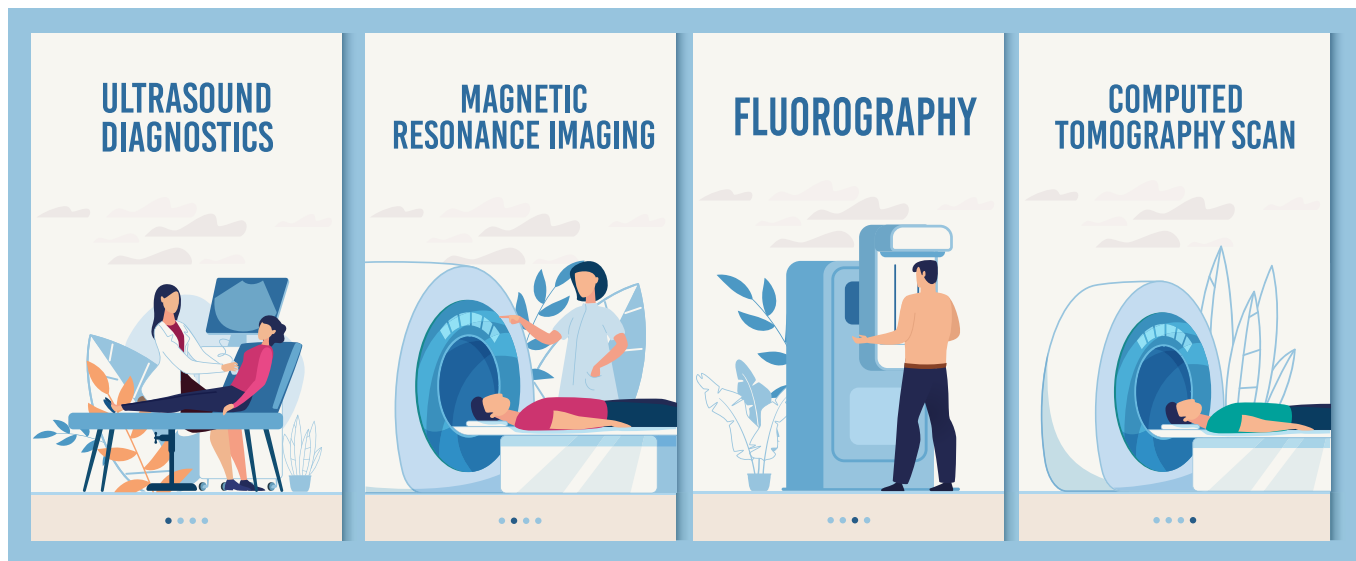
Society of Interventional Radiology sirweb.org

Society for Imaging Informatics in Medicine siim.org

Society of Radiologists in Ultrasound sru.org

Society of Skeletal Radiology skeletalrad.org

Society of Thoracic Radiology thoracicrad.org



Introduction to Resident Rotations

Introduction

The first year of radiology training is both exhilarating and nerve-wracking. To help you on this adventure, this chapter will provide an overview of the scope and responsibilities of each of the services you will rotate through during your residency. This is not intended to be comprehensive or specific to your institution, however, many of the details included are similar across the country.

BODY IMAGING

The term and section “body imaging” can include any of the following modality combinations: gastrointestinal (GI) and genitourinary (GU) fluoroscopy, computed tomography (CT), and magnetic resonance imaging (MRI) of the chest, abdomen and pelvis. The extent of what is covered on each rotation may differ and each of the modalities above may be split up separately.

Fluoroscopy: Some of the more common fluoroscopic studies performed include esophagrams, loopograms, small bowel follow-throughs, upper GI series, barium enemas and retrograde urethrograms (RUGs). Cystograms and intravenous pyelograms (IVP) have primarily been replaced by their CT counterparts. The technical component of these examinations, e.g., guiding the patient positions, obtaining the images with the fluoroscope and adjusting the settings, can be learned quickly either under the guidance of a more senior resident or an attending. The more difficult task lies in interpreting the images you have obtained and integrating them with the patient’s history. To optimize each day, prepare a list of the scheduled patients and look up their history and prior studies (including old fluoroscopic studies, CT, etc.) so you are prepared for each examination.

Fluoroscopic studies use oral or intravenous contrast to opacify the gastrointestinal or genitourinary system, respectively. Contrast administration depends on the study. Contrast options for fluoroscopic studies:

Barium: Common oral contrast used for healthy patients and outpatients. Barium is available in various “thick and thin” consistencies. Thick barium is commonly used in upper GI evaluations and colonography, and is frequently combined with effervescent crystals or air, respectively. Also, it is commonly used in modified barium swallows to evaluate swallowing mechanics and aspiration. If there is concern for GI perforation below the diaphragm, use a water-soluble agent listed in the next section.

Gastrografin/Hypaque/Omnipaque: Water-soluble oral contrast agents are commonly used for inpatients, sick patients and post-operative patients. They should NOT be used in patients at risk for aspiration. Gastrografin is a hypertonic solution and, if aspirated, can lead to flash pulmonary edema.

Computed Tomography: There are many different types of CT examinations. A protocol is the term used to describe the specific details of how a CT will be obtained. This refers to the region of the body being scanned, the slice thickness, whether IV or oral contrast will be utilized, and the timing of the imaging with respect to contrast injection.

Non-contrast CT examinations are performed primarily for renal stone evaluation; in patients who cannot receive IV contrast due to either poor renal function or a history of contrast allergy; or acute hemorrhage. Oral contrast could still be utilized if indicated to help elucidate particular pathologies.

A contrast-enhanced CT implies a single-phase intravenous contrast examination that forms the majority of the scans to be performed. Common indications include: abdominal pain, cancer evaluations and trauma, among others. Multiphasic examinations include any combination of the following: a non-contrast phase, an early arterial phase, a portal venous phase, a hepatic venous phase and/or a delayed excretory phase. Selected combinations of these techniques are used for evaluation of renal, hepatic, pancreatic and abdominal pathology. CT angiography uses some of these phases for evaluation of the thoracic or abdominal vasculature.

Timing of the described phases varies by institution, but example timing is included below:

- Early Arterial Phase: 15 seconds after the injection
- Portal Venous Phase: 35–40 seconds after the injection
- Hepatic Venous Phase: 70 seconds after the injection
- Delayed Excretory Phase: 10 minutes after the injection

Before intravenous contrast is administered, it is important to assess renal function. The creatinine (Cr) and/or estimated glomerular filtration rate (GFR) level should be checked prior to the study. Some institutions will not require these measurements for relatively healthy outpatients that do not have a history of renal insufficiency. See chapter five for more information regarding contrast administration, reactions and treatments.

Few absolute contraindications to oral contrast exist (high-grade SBO, large bowel obstruction, inability to drink), and hence it should be administered for almost all abdomen/pelvis CT evaluations if the patient can tolerate it. One can choose between two general categories of oral contrast depending on the pathology being evaluated—positive, which is bright on CT (hypaque, gastrografin, omnipaque) and negative, which is dark on CT (volumen or water).

While you may not be asked to protocol CTs as a first-year, you want to start actively participating as soon as possible. This will help you learn the indications for the exams and help prepare you for questions asked while on call.

BREAST IMAGING

Breast imaging includes mammograms (both screening and diagnostic), ultrasounds, biopsies, MRIs and ductograms. Screening mammograms are examinations performed on those with no history of breast cancer or no breast complaint and are obtained on a yearly basis. Diagnostic mammograms are performed for a number of indications including a specific breast complaint (lump, pain, nipple discharge, etc.), recent breast surgery, or a need for additional images after a screening mammogram. At some institutions, both screening and diagnostic mammograms are looked at immediately, before the patient leaves the clinic; at others, screening mammograms are read at a later time and, if necessary, the patient will return for additional images or another examination.

Breast ultrasounds may be performed by a sonographer or a physician. Some ultrasounds are targeted (imaging the region of interest only) while other examinations may evaluate the entire breast (or both breasts). At some institutions, if a patient needs a biopsy, she (he) is offered that procedure the same day; at others, the patient is scheduled to return for a biopsy on a different day. Biopsies can be performed under ultrasound, stereotactic (using mammographic images) or MRI guidance. Breast MRI has become an important exam, especially in patients at high risk for breast cancer, those with dense breasts or patients recently diagnosed with breast cancer (looking for additional lesions that would change surgical management). Ductograms are studies performed to evaluate the ductal system of the breast when a patient is complaining of nipple discharge.

CARDIOTHORACIC IMAGING

Chest rotations can include inpatient and outpatient chest radiographs (X-rays), inpatient and outpatient chest/cardiac CT and high-resolution chest CT. Chest and cardiac MRI may also fall in this department, depending on the program.

Learning how to effectively interpret a chest radiograph is the first skill you should attempt to master when beginning any cardiothoracic rotation. Develop a pattern and stick with it: tubes/lines, airway, bones, heart, mediastinum, diaphragms, lungs, corners, etc. Arrange these things in the order that works for you.

Begin by evaluating some of the important things that can easily change on chest X-ray: life support devices (endotracheal tube (ETT), central lines, etc.), pulmonary edema, airspace opacities, and pneumothorax. Learn how

to read both the two-view chest radiograph (posteroanterior (PA) and lateral) and the portable chest radiograph, obtained in the anteroposterior position (usually from the intensive care unit (ICU), inpatient floors, etc.).

During your first year, the majority of time should be spent perfecting your chest radiograph search pattern. You should become comfortable with anatomy on chest CTs and correlate them with radiographs. The chest service may read regular CT, CT angiography of the pulmonary arteries and high-resolution chest CT. While chest CT examinations can be performed for many reasons, a high-resolution chest CT is ordered for evaluation of the lung parenchyma with thin slices, looking for interstitial lung disease. Prior to starting call, you should become comfortable with studies for pulmonary embolism, as these are common studies read on call.

INTERVENTIONAL RADIOLOGY

Interventional radiology (IR) is a combination of image-guided (CT, US or fluoroscopy) procedures that may be embedded into the individual rotations that cover each body part or may be grouped together. The key to success on IR is to treat each request as a consult. To be an effective consultant you need to understand the patient's history, indications/contraindications for the procedure, laboratory values (INR, creatinine/GFR, and platelets), medications (anticoagulants), allergies and prior anesthesia. Once this information has been gathered it should be presented to the attending/fellow in charge that day. Afterward, the patient will need to be consented, so it is important to make sure that the patient is capable of understanding and giving consent or has someone with him/her that can consent for the patient. Many of these procedures are done with sedation (which will vary by institution). To receive both pain medication and sedation, the patient will need to be NPO. Due to varying local policies, please check and follow your institution's policies.

MUSCULOSKELETAL IMAGING

Musculoskeletal (MSK) radiology includes radiographs, CT, MRI and ultrasound. MSK radiographs are routinely performed for trauma (fractures/dislocations), arthritis, post-surgical films, metabolic diseases, tumors and sports injuries. As a first-year resident, focus on radiographs and anatomy. To prepare for call, learn how to accurately describe fractures (angulations, displacement and type) of the extremities and spine. Toward the end of your first rotation, tackle post-surgical musculoskeletal films that seem daunting but are important for evaluating for loosening, infection, incorrect pin/nail placement and change in position of nail/pin placement. Remember: old studies are your best friend.

NEUROLOGICAL IMAGING

Neuroradiology consists of CT and MRI examinations of the brain, face, temporal bone, sinuses, neck and spine. MRI provides great detail, especially with regard to soft tissues, while CT evaluates osseous structures, bones and acute hemorrhage. Both CT and MRI angiography evaluate the cervical and intracranial vasculature (referred to as CTA and MRA, respectively). As always, focus on brain anatomy first. As you begin your rotation, begin by interpreting head CTs. Head CTs are usually non-contrast exams for evaluation of stroke, mass or bleed. Learn basic pathologies such as subarachnoid hemorrhage, epidural and subdural hematoma, hemorrhagic and ischemic stroke,

and recognition of a mass lesion. After you become comfortable with CT, start looking at MRI. Invasive procedures, such as image-guided lumbar punctures and myelography may also be part of this rotation.

NUCLEAR MEDICINE IMAGING

Nuclear Medicine is a broad area that includes scintigraphic examinations, positron emission tomography (PET) studies and cardiovascular examinations. At some institutions, these are split into different rotations while other hospitals have them combined. Cardiovascular examinations are beyond the scope of this booklet.

The premise of nuclear examinations is that the body is imaged from the inside out. The radiopharmaceutical is administered to the patient (PO or IV) and travels to the particular tissue to which that tracer localizes. The administered radiopharmaceutical emits radiation and the nuclear medicine camera (SPECT camera, for example) images the distribution of the material in the body.

Once an examination has been performed, the technologist will ask you to look at the initial images and decide if additional images are needed. If additional images are required, you may need to specify what projection you need. For example, if it is difficult to differentiate between a loop of bowel and the gallbladder on a hepatobiliary examination, a lateral image can be obtained.

PET imaging is conceptually similar, in that the radiopharmaceutical is injected and images are taken later. However, the camera functions differently. There are many applications for PET, but the primary use is for cancer imaging, which can be initial staging, follow-up staging and response to therapy.

PEDIATRIC IMAGING

Pediatric radiology usually involves radiographs (chest, bone and abdomen), CT, ultrasound, fluoroscopy, MRI and neuroradiology.

There are many types of radiographs performed on children, especially if you are at a hospital that has a pediatric intensive care unit. Again, learn the normal anatomy as seen on pediatric radiographs. Another important topic to master is life support devices used in the neonatal intensive care unit (NICU), which differ from adult patients (mainly umbilical venous and arterial catheters).

While CT and MRI are important imaging tools in pediatric, ultrasound is a first-line tool because no radiation or sedation is imparted. For CT and MRI protocols, oral and intravenous contrast doses are calculated according to patient weight, rather than being standard as in adult CT and MRI. In addition, for CT, the amount of radiation imparted should be minimized in children and is also calculated according to patient age and weight.

Fluoroscopy is an important component of pediatric imaging and will include examinations for gastroesophageal reflux disease, malrotation, vesicoureteral reflux and obstruction. Depending on the number of fluoroscopic studies each day, this portion of pediatric imaging may be covered by one resident. As with adult fluoroscopy, preparation is key.

Contrast agents given during fluoroscopic imaging are different for children than those used with adults and vary by institution. Gastrografin is typically not used in children, but refer to your own institutional policies for further guidelines.

ULTRASOUND IMAGING

Inpatient and outpatient ultrasound examinations include: abdominal, pelvic, thyroid, soft tissue and Doppler studies. At some institutions, obstetric and vascular studies may also be interpreted and performed by a radiologist. During your first rotation, learn to perform the examination yourself under supervision to better understand the anatomy. Do NOT be afraid to ask the sonographers for assistance. This will help, as there will be times when you may need to scan a complex case yourself in order to fully understand it. At some programs, you will be performing the exams yourself on call.

All examinations will have gray-scale images that demonstrate anatomy (and pathology). Color-Doppler and spectral-wave form evaluations are used to evaluate the vasculature (patency, direction of flow and velocity).

Radiation Safety

Radiologists are responsible for patient safety when using modalities that impart ionizing radiation. The benefits of the examination must outweigh the potential hazards. You will often hear the acronym “**ALARA**” when discussing medical radiation exposure. This stands for “**A**s **L**ow **A**s **R**easonably **A**chievable” and is a part of the safety principle for keeping radiation exposure to the minimum. This means that radiation exposure should be limited to only what is necessary to achieve an appropriate diagnostic study.

It is also important to limit radiation exposure to ourselves and other medical professionals. The following is an introduction to radiation safety and a quick reference guide for commonly encountered questions in day-to-day practice.



RADIATION BASICS

Ionizing radiation injures organs and tissues by depositing energy. The amount of damage is dependent upon the amount of energy deposited (dose) and the sensitivity of the tissue irradiated. Different tissues have variable sensitivity to radiation exposure; for example, the bones and soft tissues of the hand are much more resistant to radiation exposure than the glandular tissues of the breast or thyroid.

When comparing doses for different exams, the term “equivalent dose” is used, because not all types of radiation cause the same biologic damage per unit dose. In other words, some kinds of radiation are more harmful than others, even when they transfer the same amount of energy to the tissues. The equivalent dose modifies the dose to reflect the relative effectiveness of the radiation using a weighting factor. This gives an **approximate** indication of the potential harm from ionizing radiation. When determining individual risk, one must consider the patient’s age,

sex and the type of tissues exposed to the radiation. In diagnostic radiology and nuclear medicine, the types of energy used are similar, so the same weighting factor is used.

The “absorbed dose” is the amount of radiation absorbed per unit mass of a medium and depends on the particular material or tissue in the radiation field. It should be noted that in addition to the total amount of radiation absorbed, the time period over which it is absorbed matters. A dose divided over several episodes is less harmful than the same amount of radiation given in a single dose. This principle explains how “fractionating,” or dividing, radiation given to treat malignancies reduces toxicity to normal tissues. The prevailing theory for this phenomenon is that tissues have time to recover and repair or discard damaged cells in between doses.

Common terms and common equivalents:

Roentgen (R): A unit of radiation exposure. Exposure is used to express the intensity, strength or amount of radiation in an X-ray beam based on the ability of radiation to ionize air.

Rad (rad): Radiation Absorbed Dose measures the absorbed dose described above.

Rem (rem): Measures radiation specific biologic damage in humans and is used for equivalent dose.

1R = 1 rad = 1 rem.

Most countries now use the Standard International (SI) units to express these quantities, including Sieverts (Sv) and Grays (Gy). However, in the United States, the above terms (R, rad and rem) are still used at times.

1 Sv = 100 rem

1 Gy = 100 rad

Table 1

Background Radiation Source	Effective Radiation Dose
Radon	2 mSv/yr
Smoking	2.8 mSv/yr to the lungs
Cross country flight	0.01 mSv each way
Two-week vacation in the mountains	0.03 mSv
Nuclear weapons testing	0.05 mSv/yr
Living in a brick home	0.35 mSv/yr
Luminous radium dial watch	36 mSv/yr to the wrist
Brightly glazed ceramic tableware (uranium in glaze)	5–24 mSv/yr to the hands
Average medical exposure per U.S. resident	2.4 mSv/yr, (60% from CT)
Living in Denver	6 mSv/yr

Table 2

Procedure	Average Adult Effective Radiation Dose	Comparable to Natural Background Radiation for:
CT Abdomen and Pelvis	7–10 mSv	3 years
CT Head	2 mSv	8 months
Chest Radiograph	0.1 mSv	10 days
CT Thoracic/ Lumbar Spine	10 mSv	3 years
Lumbar Spine AP Radiograph	0.7 mSv	2 months
Mammography per view	0.2 mSv	20 days
Bone Density Exam (DEXA)	0.01 mSv	1 day
Barium Enema	7–10 mSv	3 years
CT Chest PE Protocol	~13 mSv	5 years
Three-Phase Liver Protocol CT	15 mSv	5 years

BACKGROUND RADIATION

We are all exposed to background radiation in our daily life. The average amount of background radiation exposure in the United States is 3 mSv per year; the largest contributor to this amount is radon. The tables below list the effective doses of different radiation exposures (Table 1) and some radiologic examinations (Table 2).

RADIATION AND CANCER

The most important delayed effect of radiation exposure is cancer induction. The difficulty in estimating this risk is due to the high lifetime frequency (up to 40%) of naturally occurring malignancy. Radiation induced cancers have a latency period of 10–20 years. Based on the Biological Effects of Ionizing Radiation (BEIR) VII report, it is estimated that approximately one in 1,000 persons will develop cancer from an exposure of 10 mSv. This risk is very small compared with the natural lifetime incidence of cancer of 400 of every 1,000 persons. The risk also varies for the age of the patient. Pediatric patients have much higher potential lifetime risk than do adults with the same radiation exposure, due to the greater sensitivity of their immature tissues as well as their longer remaining expected life span.

There are two types of biologic effects of radiation exposure: stochastic (probabilistic) and deterministic. Deterministic effects of radiation are characterized by a threshold dose and are dose dependent; below a certain dose, the effect does not occur but as the dose increases above threshold, the probability of an event occurring also increases closer to 100%. The severity of deterministic effects also increases with the dose. Examples include lethality, cataract induction, skin erythema and sterility. Deterministic effects are due to cell death. Stochastic effects, on the other hand, deal with the probability of an occurrence; as the dose increases, there is an increased chance of having a stochastic effect. The severity of the stochastic effect/disease is independent of the dose. An example of a stochastic effect is cancer and genetic damage.

Learn more about minimizing radiation risk on imagewisely.org.

RADIATION AND CHILDREN

Children are especially vulnerable to ionizing radiation due to increased sensitivity of developing tissues and organs and longer latency. The latency period for radiation-induced malignancy varies, but is approximately 10 years for leukemia and longer for solid tumors. Radiation-induced cancer mortality risk in children has been estimated to be 3–5 times greater than adults. However, the overall risk of radiology remains very low, and the risk of morbidity and mortality from the disease may be much higher.

Learn more about radiation and its effect on children on imagegently.org.

Table 3

Procedure	Estimated Effective Dose for a 5-year-old Child
PA and Lat Chest Radiograph	0.02 mSv
AP and Lat Abdomen Radiograph	2.5 mSv
Voiding Cystourethrogram (VCUG)	1.6 mSv
Head CT	4 mSv
Chest CT	3 mSv
Abdomen CT	5 mSv

RADIATION AND PREGNANCY

Imaging the pregnant patient is a common clinical dilemma. You need to speak to pregnant patients about radiation concerns and should be prepared for questions regarding the safety of the patient and the fetus. Risks associated with imaging in pregnancy are largely dependent upon the fetal age at the time of the examination and the type of study being performed. Although estimated radiation doses have been calculated for various examinations, most of the data upon which they are based was extrapolated from observation of children with heavy radiation exposure born after Hiroshima and Chernobyl. Radiation dose thresholds for fetal malformations, miscarriage, mental disorders and neurobehavioral effects are all greater than 100 mGy, or greater than approximately 100 mSv in a single dose.

For single-exposure doses below 100 mGy, the radiation risks are deemed low when compared to the normal risks of pregnancy. For medical personnel and workers, fetal exposure should be measured by way of a dosimeter on the mother's abdomen.

With the pre-implanted embryo, radiation effects are all or nothing — the embryo implants or does not. Radiation-induced noncancerous health effects are unlikely at this stage regardless of radiation dose. The fetus is most vulnerable to radiation exposure during the first trimester, especially during days 20–40 post conception. Radiation-induced microcephaly is the most common abnormality associated with exposure. Growth retardation and mental impairment occurs 70–150 days post conception. For fetuses exposed between 8–15-weeks'

gestational age, atomic bomb survivor data indicates a decline in IQ score of 25–31 points for every 1000mGy above 100mGy.

The oncogenic risks to the developing embryo/fetus are quite controversial. The embryo/fetus is thought to be no more sensitive to these effects than a young child. There appears to be a slightly increased incidence of childhood cancer with direct in utero exposures greater than or equal to 10 mGy. There is no evidence that shows that this effect is dependent upon gestational age. It has been postulated that for 10mGy exposure there will be one extra case of cancer per 10,000 (0.01%). Note that this effect assumes 10 mGy direct exposure to the fetus, after taking into account the protective effects of the surrounding maternal soft tissues, which scatter the majority of the radiation imparted to the maternal abdomen. Natural background risks include 3% birth defects, 15% miscarriages, 4% prematurity, 1% mental retardation and 4% growth retardation. Natural background risks are much greater than what one would estimate the risk from exams in standard diagnostic radiology. The takeaway is that pregnant workers must take extra care to protect their fetus and should utilize extra shielding and dosimeters.

Table 4
Maximum Estimated Fetal Dose (mGy) With Common Exams

EXAM	VIEW	MEAN	MAXIMUM
Chest	PA	<0.1	<0.1
Thoracic Spine	AP	<0.1	0.03
Hip	Lat		0.5
Lumbar Spine	AP	7.5	40
Lumbar Spine	Lat	0.91	3.5
Pelvis	AP	3.4	22
CT Head			<0.5
CT Chest			<1
CT Abdomen			26

From: perinatology.com/exposures/Physical/Xray.htm

References:

- Bushberg, Seibert, Leidholdt and Boone. *The Essential Physics of Medical Imaging*. 1994. Baltimore: 55–56.
- imagegently.org
- Huda, Sloan. *Review of Radiologic Physics Second Edition*. 2003. Philadelphia: 41–42.
- radiologyinfo.org

Intravenous Contrast

When administering intravenous contrast, the radiologist should utilize all available information to determine whether the study is appropriate and whether contrast is indicated for the study. The goal of the radiologist is to optimize imaging utilization while minimizing the likelihood of any adverse reactions. It is also the radiologist's responsibility to stay informed on scientific advances in contrast agents and their adverse reactions and treatments.

Types of Contrast Agents

Iodinated contrast. Iodinated contrast agents can be classified as either ionic or nonionic, and high-, low-, and iso-osmolar (HOCM, LOCM, IOCM, respectively). Agents used today are most commonly low-osmolar and iso-osmolar agents. Low-osmolality agents have osmolality approximately twice that of human serum and iso-osmolality agents have osmolality similar to human serum. Specifically, low-osmolality nonionic monomers are the most common. This agent is newer and now most commonly used because it has less adverse reactions than its older counterparts. Iodinated contrast agents are excreted primarily via the kidneys.

Gadolinium. Gadolinium can be classified as extrahepatic or hepatobiliary. Extrahepatic contrast is excreted primarily via the kidneys while hepatobiliary contrast is excreted 50% via the kidneys and 50% via the biliary system. An important risk of gadolinium is nephrogenic systemic fibrosis (NSF), an idiopathic systemic disorder characterized by widespread tissue fibrosis. Signs and symptoms can be seen within two weeks and include extremity edema and swelling, myalgias and weakness. Later signs include skin fibrosis with thickening and tightening, resulting in contractures most commonly in the lower extremities. Systemic features include fibrosis of the pericardium, myocardium, pleura, lungs, skeletal muscle, kidneys and dura.

Agents with higher risk of NSF	Gadodiamide (Omniscan®) Gadopentetate dimeglumine (Magnevist®) Gadoversetamide (OptiMARK®)
Agents with lower risk of NSF	Gadobenate dimeglumine (Multihance®) Gadoteridol (ProHance®) Gadoteric acid (Dotarem®) Gadobutrol (Gadavist®)

Additional agents such as carbon dioxide (angiography), iron oxide (MRI) and manganese (MRI) are also utilized, but are not discussed here.

Precontrast Assessment

The following should be assessed for every patient before contrast administration:

- **Renal function** — see “Contrast-Induced Nephrotoxicity.”
- **Pregnancy status** — see “Pregnancy.”
- **Allergy history** — In addition to adverse reactions to imaging contrast, atopic patients are at 2–3 times increased risk for an adverse contrast reaction. Patients with a history of anaphylaxis in particular should have the risks and benefits of contrast administration reviewed with the referring clinician. There is no cross-reaction between contrast and shellfish.
- **Metformin use** — Metformin does not increase risk of nephropathy but can lead to lactic acidosis in patients with renal failure. Therefore, the current ACR Manual on Contrast Media recommends not to discontinue Metformin use in patients with normal renal functions while patients with multiple comorbidities or renal dysfunction should discontinue Metformin for at least 48 hours. Actual practice will vary by institution.

Additional considerations include pheochromocytoma if direct injection into the adrenal or renal artery is being considered. Use of contrast in patients with myasthenia gravis is controversial.

Contrast-Induced Nephrotoxicity (CIN)

The most commonly used indicators for renal disease are serum creatinine (Cr) and glomerular filtration rate (GFR). There is no universally accepted time frame for renal function assessment before contrast administration. Factors such as age, history of renal disease, hypertension and diabetes should be used for decision making. A renal function threshold has also not been established for contrast administration and will vary by institution and radiologist. The risks and benefits of contrast administration should be discussed with the referring physician. Patients with end-stage renal disease are not at risk for CIN. Unless there is a high-contrast load, there is no need for urgent dialysis following contrast administration.

The AKIN criteria defines acute kidney injury due to contrast administration as the following occurring within 48 hours:

- Serum creatinine ≥ 0.3 mg/dl.
- Serum creatinine $\geq 50\%$ above baseline.
- Reduced urine output to ≤ 0.5 mL/kg/hr for at least five hours.

The elevation in serum creatinine peaks at days 7–10 and usually returns to baseline within two weeks. Very few people go on to develop long-term renal failure. At-risk patients should be well-hydrated or administered fluids before and after the administration, such as 100ml/hr 6–12 hours prior and 4–12 hours after. The use of sodium bicarbonate and N-acetylcysteine remains controversial.

Premedication

Medication prior to contrast administration should be considered in patients at higher risk for adverse allergic reactions. Ionic and high-osmolality contrast agents have a higher potential to produce reactions. Exact protocol will vary by institution. Two examples in adults patients are provided below:

1. Methylprednisolone 32mg PO 12 and two hours before administration. An antihistamine can be added.
2. Prednisone 50 mg PO 13, 7, and one hour prior to administration PLUS diphenhydramine (Benadryl®) 50 mg PO, IM, or IV one hour prior to administration.

Emergent premedication can be performed with methylprednisolone 40 mg or hydrocortisone sodium succinate 200mg IV every four hours until scan PLUS diphenhydramine 50mg IV one hour prior to injection. The radiologist should be prudent of breakthrough contrast reactions despite premedication.

Injection of Contrast

Contrast should be injected by power-injector using a 20-gauge needle or larger, though use of a 22-gauge needle may be possible with the appropriate bolus size and flow rate. The antecubital fossa is preferred. If the more distal extremity is to be used, the injection rate should be lowered according to the manufacturer's instructions. The radiologist should consult manufacturer instructions regarding use of other catheters. Contrast should not be given through small peripheral catheters. Before use, all catheters should be checked for position and test injected with saline.

Types of Contrast Reactions and Their Treatment

Reported rates of reaction with low-osmolar contrast media are 0.2–0.7%. Serious reactions are rare at 0.04%. Contrast reactions range from a cold sensation at the injection site to life-threatening anaphylaxis. The radiologist should be knowledgeable of all contrast agents used at their institution and their treatments. Advanced procedural drills should be practiced so the radiologist is familiar with the equipment available to them at each scanner.

There are two types of reactions: idiosyncratic and nonidiosyncratic. Idiosyncratic reactions (urticaria, pruritis, facial edema, bronchospasm, palpitations, tachycardia, bradycardia, pulmonary edema, life-threatening arrhythmias) begin within 20 minutes of contrast injection and present identical to an anaphylactic reaction. However, because there is no antigen-antibody response, these reactions are classified as "anaphylactoid" or "non-allergic anaphylactic." Treatment is identical to that for an anaphylactic reaction.

The treatment of contrast reactions are listed below. For more severe reactions, the treatment also includes monitoring of vitals, preservation of intravenous access and oxygen via mask.

Brief summary of reactions and their treatments adopted from the ACR Manual on Contrast Media (2020). Please see the ACR Manual on Contrast Media for more details.

Reaction	Treatment
Extravasation	Elevation, warm or cold compresses. Surgical consultation if severe, worsening pain and swelling, decreased perfusion.
Mild hives Moderate to severe hives	No treatment or diphenhydramine (Benadryl®). Diphenhydramine.
Diffuse erythema	If normotensive, no treatment. If hypotensive, fluids. If profoundly hypotensive or unresponsive to fluids, epinephrine. Call emergency response team or 911.
Mild bronchospasm Severe bronchospasm	Beta agonist inhaler (Albuterol®). Epinephrine. Call emergency response team or 911.
Laryngeal edema	Epinephrine. Call emergency response team or 911.
Hypertensive crisis	IV labetalol. Call emergency response team or 911.
Hypotension (SBP <90mmHg)	Elevate legs at least 60 degrees, fluids. If severe and bradycardic (vasovagal reaction), atropine. If severe and tachycardic (anaphylactoid reaction), epinephrine. Call emergency response team or 911.
Unresponsive or Pulseless	Start ACLS. Call emergency response team or 911.
Pulmonary edema	Elevate head, IV furosemide (Lasix®).
Seizures	Turn patient onto decubitus position, suction airway if needed. Call emergency response team or 911.
Venous air embolism	100% oxygen, left lateral decubitus position. Consider hyperbaric oxygen.

Other Contrast Reactions

Contrast agents themselves can cause sensations of warmth and discomfort. Patient anxiety can manifest as a range of nonspecific symptoms including nausea, dizziness, chest pain and shortness of breath. Care should be made to differentiate anxiety from a true contrast reaction. Patients can also develop delayed contrast reactions an hour to several days after the initial injection, the most common of which are cutaneous and rarely “mumps-like” symptoms. Patients with thyroid disease such as hyperthyroidism can develop hyperthyroidism 4–6 weeks after injection and is usually self-limited.

Pregnancy

Iodinated contrast. Intravenous contrast should be given with caution in the pregnant female. Although there has been no reported case of an adverse effect on human fetuses, adequate studies are limited. Before intravenous contrast is administered to a pregnant patient, the radiologist is advised to document the need for intravenous contrast. This includes stating that the study cannot be acquired without contrast or by another modality, and that the referring physician affirms that the study affects patient care and should not be delayed until after delivery.



Gadolinium. Although there has been no reported case of NSF in pregnant patients and human fetuses, gadolinium chelates may accumulate in amniotic fluid with the potential formation of toxic free gadolinium ions. Therefore, intravenous gadolinium should be avoided in pregnant patients.

Breastfeeding

The iodinated contrast and gadolinium dose absorbed by the breastfeeding infant is less than 0.01% and 0.0004% of the initial dose given to the mother for iodinated contrast and gadolinium, respectively. Therefore, the ACR Manual on Contrast Media (2020) states that breastfeeding mothers can continue to breastfeed following the administration of intravenous contrast without interruption. However, if the mother remains concerned about potential adverse effects of intravenous contrast on the infant, she can be advised to express and discard the breast milk for 12–24 hours. Of note, contrast excretion into breast milk can alter its taste to the infant.

The Radiologist's Report

Components

The radiology report can be divided into six main sections:

1. **Clinical history** — patient's age, sex, current presenting symptom, and any relevant medical and surgical history. Adequate clinical history is critical in shortening the differential diagnosis and providing a valuable impression. Review the patient's medical records and call the clinician for more information if needed.

Example: 87-year-old male nursing home resident presents with acute shortness of breath for one hour with left-sided chest pain on respiration. Past medical history of colon cancer and recent history of right lower extremity DVT on anticoagulation.

2. **Technique** — Describe the examination in detail. Include the modality, amount and route of contrast administration, acquisition thickness (CT), sequences (MRI), and use of spectral and duplex analysis (US). Post-processing with production of additional 2D planes and 3D images should also be included. Factors that adversely affect interpretation should be included. This information can be used to convey information to other radiologists and clinicians about what diagnostic information is available and what the interpretative limitations are. In addition, if there is any deviation from usual protocol, that should be stated here as well (e.g., intravenous contrast was withheld secondary to the patient's renal failure, additional SST2W short axis sequenced performed in 8 mm from the heart to the apex).

Example: Axial helical chest CT was obtained without the administration of intravenous contrast at 2.5 mm intervals. Axial MIP reconstructions and 2D coronal and sagittal reconstructions were also performed.

3. **Comparison** — Use comparisons liberally across all modalities. There is nothing like trying to figure out what a lesion on ultrasound or CT is when the finding is diagnostic on an MRI three years ago. The modality, use of contrast and date should be included. If there are multiple studies of the same date, mark the time of examination as well. Inclusion of time is particularly important for multiple studies performed over a short period, such as ICU chest X-rays.

Example: Portable supine radiograph dated 03/14/2015 at 4:15am, portable supine radiograph dated 03/14/2015 at 5:14am, abdominal/pelvic CT with oral and intravenous contrast dated 8/15/2014, abdominal MRI without and with intravenous contrast dated 6/13/2012.

4. Findings — The size, shape, margins and tissue characteristics compared to adjacent tissue (e.g., intensity, density, echogenicity, pattern of enhancement), location and change compared to prior studies. It is also equally important to include important negative findings.

Example: A new 1.0 x 1.4 x 2.1 cm well-circumscribed round homogeneously hypodense lesion is present in segment 4 of the liver. There is no enhancement on postcontrast images.

5. Impression — The impression should specifically address the referring physician's question. A specific diagnosis should be given, when possible and a succinct differential, if needed, utilizing the clinical information. All findings should be compared to prior studies and interval change should be described. Suggested further imaging and management should be stated here. Any study limitations and adverse reactions should also be documented.

Example: 1.0 cm left convexity subdural hematoma with 3 mm rightward midline shift. No herniation.

6. Communication — All critical findings should be verbally communicated with the referring clinician and documented in the report. State who you spoke with and the time.

Examples: These findings were discussed with Dr. Smith via telephone at 4:50pm on 3/14/2020.

Before submission, proofread the report for any discrepancies and spelling and grammar errors. For on-call residents, the report should explicitly state both the final and initial report to minimize confusion regarding the initial care by subsequent clinicians. Many dictation software have options to automatically label reports as preliminary vs. final read.

Many residents utilize templates when they first begin. Eventually you will decide what to leave in and what to take out of your final report. Following up the final attending overread is a high-yield learning opportunity, as it not only allows you to learn from any diagnostic errors, but also provides insight into ways you can improve your wording and overall diction construction.

Billing

Proper documentation of study indication and technique are important for billing. A poor or incomplete report may be incorrectly coded or coded to a study worth less in reimbursement. Both the CPT® and ICD codes are needed to apply for reimbursement.

CPT: CPT stands for the American Medical Association's Current Procedural Terminology and refers to a diagnostic radiology, medical or surgical service, and is designed to communicate uniform information between the services. It states the price of an exam, patient visit or procedure compared to other medical services. Each scan is assigned a relative value unit (RVU). Reimbursement by Medicare is based directly on the RVU.

ICD: ICD stands for international classification of diseases. It is a code for symptoms or disease. For example, cough, abdominal pain and claudication all have ICD codes.

Simply put, each report should have the examination type (CPT) and disease or symptom of the patient (ICD). The former is easy to satisfy and is why the “technique” section is so important. The latter is more difficult to satisfy and is why you have been told clinicians state “rule out pulmonary edema” as the clinical history. Rule out pulmonary embolism does not have an ICD code and thus the study is not reimbursable. There is an important exception to this. The coders are allowed to place a primary ICD code from your findings or impression. That is, if the study does show a pulmonary embolism, then the ICD code for the disease “pulmonary embolism” is coded.

Report Types

There are initiatives to change the radiology report from a free narrative dictation to a standardized structured text. The argument for more standardized reports is that narrative reports are tedious and sometimes unclear, while uniform standardized reports are easier for referring providers to interpret. Standardized reports also provide a basic framework to follow, which is particularly helpful for beginning radiology residents to ensure they evaluate each important structure in a given exam.

Example of free narrative report: The liver, spleen, pancreas and kidneys are unremarkable. Multiple small stones are present within the dependent gallbladder lumen. There is no evidence of cholecystitis. A stable 1.0 cm left adrenal adenoma is noted.

Example of structured report:

LIVER: Within normal limits.

BILIARY SYSTEM: Multiple small gallbladder stones. No cholecystitis.

SPLEEN: Within normal limits.

PANCREAS: Within normal limits.

ADRENAL GLANDS: Stable 1.0 cm left adrenal adenoma.

KIDNEYS: Within normal limits. No hydronephrosis.

Universally adopted structure reporting include the BI-RADS® system for reporting mammography with recent expansion to liver lesions and pulmonary lesions.

Sample Dictations

Sample dictations can be found on numerous websites. Below is an example:

radreport.org



Introduction to Fellowships

Nearly all radiology residents now pursue additional subspecialty training beyond residency. In addition to the increasing emphasis on sub specialization in Medicine, the new ABR certification exam requires general competency as well as subspecialist competence. Although the majority of radiology jobs are still general positions, as practices consolidate and call is increasingly taken internally rather than by teleradiology companies, there has been increasing demand for fellowship training. Finally, a competitive job market has prompted residents to delay entering the workforce to further increase their credentials.

There are many subspecialties in radiology and choosing may not be simple. Maximizing your time in every subspecialty is crucial. In addition to the common subspecialties within radiology, it is also important to obtain adequate exposure in less common subspecialties such as cardiac imaging. If your institution has limited exposure in a particularly subspecialty, look into away rotations to supplement both your education and experience. Speak with your attendings and past residents for advice and ask how they decided on their specialty and what factors went into making that decision. Do not be afraid to ask others outside your institution at conferences for their advice as well.

Just as with jobs, every situation is different among fellowships; there is significant variation between institutions' programs. With that in mind, the following is intended to be a summarized list and description of fellowships available in radiology.

Application timelines vary by subspecialty. Many radiology fellowships now participate in the NRMP Match, including Breast Imaging, MSK, Interventional Radiology and Neuroradiology. Each institution has its own deadline. Research each institution you are interested in and take note of their application timeline. If none is posted, contact the department coordinator for more information. Rank lists are submitted starting early March/late April, and close early June. Match Day is mid-June. This varies slightly each year.

All remaining non-NRMP subspecialties usually start accepting applications starting July of the third radiology year, though some may accept a few months later. Research each institution you are interested in and take note of their application timeline. Remember to ask for recommendation letters early as attendings may be away for vacation during the summer months. Because there is no official match program, acceptances will be announced on a rolling basis. Given this, it would be beneficial to schedule your higher ranking programs before your lower ranking programs to avoid the unfortunate situation of an acceptance call from a less desirable program when your interview at a more desirable program is still pending.

ABDOMINAL/BODY IMAGING

Abdominal imaging fellowships focus on imaging of the abdomen and pelvis. Fellows can expect to gain additional expertise in evaluation of gastrointestinal and genitourinary pathologies with MRI, PET, US and CT. In addition, most abdominal divisions perform the relevant image-guided procedures such as drain or tube placement, biopsy and ablation. There is significant variability among institutions regarding their emphasis on different modalities and procedures as some may even include vascular or cardiothoracic training. Dedicated Abdomen MR experience can range from as few as two months to up to nine months in MR-predominant fellowships. CT colonography training may also be offered, although volumes are highly variable by fellowship.

CARDIOTHORACIC IMAGING

Cardiothoracic imaging fellowships offer further training in cardiac and/or thoracic pathologies. With significant variation among programs, fellowships can emphasize thoracic imaging, cardiac imaging or a combination of both. Some divisions perform their own thoracic interventions such as lung biopsy or thoracentesis. Due to interest from cardiologists, training programs may be composed of both radiology-trained and cardiology-trained fellows.

MAMMOGRAPHY/WOMEN'S IMAGING

Mammography fellowships train radiologists in the imaging of the breast. Modalities include screening and diagnostic mammogram, US and MRI. Expertise will also be gained in image-guided procedures including stereotactic, US and MRI-guided breast biopsies. Training in newer technologies such as tomosynthesis and whole breast ultrasound may also be provided. More comprehensive women's imaging fellowships may offer additional training in genitourinary pathologies specific to women including obstetric ultrasound, pelvic MRI and sonohysterography. The demand for radiologists trained in breast imaging is strong and even those individuals trained in other subspecialties may find themselves interpreting screening mammograms for their group.

MUSCULOSKELETAL IMAGING

Musculoskeletal imaging fellowships offer extra training in imaging of osseous and soft tissue pathology. Fellowships may vary significantly between institutions in their focus on certain modalities and also the variety of clinical interest such as sports medicine, trauma or cancer. Fellows often also receive training in interventional procedures such as image-guided biopsy and ablation, or joint and spine injections including myelography.

NEURORADIOLOGY/HEAD AND NECK RADIOLOGY

Neuroradiology fellowships train radiologists in imaging neurologic pathologies of the brain, spine and peripheral nervous system. Fellows will interpret CT and MRI of the nervous system as well as advanced imaging, including MR spectroscopy, PET, SPECT and functional MRI. Pediatric neuroradiology and Head and Neck radiology require different skill sets, and institutions differ in their focus on these areas. There are even dedicated fellowships available for those with these more focal interests. Trainees will usually become proficient in myelography and lumbar puncture, with some programs offering exposure to biopsies of the head and neck or blood patch placement for CSF leaks. Neuroradiology programs usually have some training in diagnostic angiography, although this has been largely relegated to Neurointerventional Radiology. Of note, neuroradiology programs can be one or two years in length based on institution and fellow preferences.

NUCLEAR MEDICINE

Nuclear medicine fellowships train radiologists interested in the use of radioisotopes for imaging and treating pathology. Training will include in-depth understandings of radioisotopes and protocols based on specific patient needs. There has been renewed interest in nuclear medicine as new radioisotopes become available for functional imaging and oncologic therapies. Nuclear medicine can be either a stand-alone fellowship, or you may be able to complete the accelerated 16-month pathway during your residency. If your residency program is approved for the 16-month pathway, you will spend 12 months in nuclear medicine rotations and four months in nuclear medicine-adjacent rotations to qualify (almost any radiology rotation can qualify as the nuclear medicine-adjacent rotation). Be wary of the number of radiopharmaceutical therapies you need to participate in for the 16-month pathway—it is significantly higher than the three high-dose and three low-dose therapies needed for residency graduation requirements.

PEDIATRIC RADIOLOGY

Pediatric radiology fellowships train radiologists in the imaging and treatment of pediatric pathology. Due to a particular emphasis on low-dose and non-invasive modalities, there is an emphasis on radiography and ultrasound, although CT and MRI are routinely used when appropriate in this population. In fact, all modalities and all body systems fall under the purview of pediatrics, making them truly “general” radiologists. Interventional procedures may also be part of pediatric fellowship training; however, this varies by institution. There are also programs available in subspecialties of pediatrics including, but not limited to, nuclear, musculoskeletal and neuroradiology.

VASCULAR AND INTERVENTIONAL RADIOLOGY (VIR)

Interventional radiology fellowship trains radiologists in the diagnosis and treatment of pathology by using image-guided percutaneous, minimally invasive procedures. Performance of some procedures such as arterial work for peripheral vascular disease and AAA repair will vary by institution. There has been increasing interest in interventionalists admitting patients to the hospital, performing rounds and seeing patients in clinic. New treatments are emerging with the invention of new devices and procedures.

Of note, with the new integrated interventional radiology residencies, the true two-year fellowship is slowly being phased out, although an end-date for these fellowships is not specified. Most programs are now accepting one-year “residents” who have completed the Early Specialization in Interventional Radiology pathway at his or her own institution.

NEUROINTERVENTIONAL RADIOLOGY

Neurointerventional radiology training prepares radiologists for image-guided diagnosis and treatment of neurological disease, with an emphasis on vascular interventions such as for stroke or aneurysm. Although originally composed of predominantly radiologists, this fellowship has gradually expanded to include neurological surgeons and even neurologists seeking this extra training. The training programs vary in number of years but may include an enfolded neuroradiology fellowship. This is desirable as most radiologists with this training will spend part of their time interpreting studies in addition to performing neurointerventions.

EMERGENCY RADIOLOGY

Emergency radiology is a newer subspecialty which focuses on the imaging diagnosis of acute pathologies of the entire body. Traditionally, radiologists with a variety of subspecialty backgrounds took general call or worked for teleradiology groups interpreting acute pathology across all body systems and modalities. However, as demand for quicker turnaround times and subspecialty final interpretations became more prevalent, there has been an emphasis on having radiologists trained in the interpretation of emergent imaging. As more academic centers establish emergency divisions and private practices bring back overnight call, there is expected to be an increased demand for this subspecialty.

NON-TRADITIONAL/NON-CLINICAL TRAINING OPPORTUNITIES

There are many opportunities in formal training outside of the more typical fellowship opportunities. For example, there are fellowships focused on interpretation of PET/CT or cardiac MRI or even performing MR-guided procedures. There are also non-clinical or indirectly clinical fellowships including informatics, management, quality and safety, research, and medical education. If these possibilities interest you, you should speak directly to faculty about options, because many of these positions are not published and only offered intermittently. Traditional post-graduate programs are sometimes also pursued by radiologists based on their interests or career goals including JD, PhD, MPH or MBA degrees.

Resident Educational Resources

Online Resources

[Radiographics](#) — Journal published by RSNA which features educational review articles in imaging. (Subscription)

[American Journal of Roentgenology](#) — Journal published by ARRS. (Subscription)

[e-Anatomy](#) — Comprehensive interactive guides to imaging anatomy. (Subscription)

[STATdx](#) — Encyclopedic guide for review of imaging abnormalities including differential diagnoses and example cases. This resource also includes modules for learning imaging anatomy in all modalities. (Subscription)

[Radiology Education](#) — Comprehensive list of educational resources in radiology sorted by topic.

[Radiology Assistant](#) — Online learning modules in many topics with excellent graphics and images.

[Learning Radiology](#) — Online learning modules in a variety of topics with weekly cases and online quizzes.

[ACR Case in Point](#)[®] — Imaging cases with didactic format including a quiz and summary.

[Radiopaedia](#) — Free educational resource with a large collection of articles and cases.

Board Preparation/Question Banks

Primer of Diagnostic Imaging

ISBN-13: 978-0323065382

Outline format for comprehensive review of radiology.

Radiology Review Manual

ISBN-13: 978-1609139438

Comprehensive reference for review of imaging anatomy and diagnosis.

Crack the Core Volumes 1 and 2

ISBN-13: 978-1537637051 & 978-1673777888

Comprehensive reference for Core Exam Review.

Radiologic Physics - War Machine

No ISBN available.

Comprehensive physics review.

[RADPrimer](#) — Question bank for board preparation sorted by topic and modality with a quiz function that tracks your progress including strengths and weaknesses. (Subscription)

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