Getting Started: A Guide to Year One of Radiology Residency

ACR Resident and Fellow Section
FOREWORD

There are many resources available throughout residency that will help you learn radiology: books, mentors, colleagues, faculty and the internet. However, nothing quite prepares you for the first day, week or year of your residency in radiology. After spending 12 months as an intern, implementing the knowledge learned in medical school, the transition to radiology may not be as comfortable as one would hope. It is, however, exhilarating to finally learn and practice skills that will be used throughout your career. In developing this handbook, the authors hope to take away some of the unknown and replace it with tools that will help make you a superb radiology resident.
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1: THE TRANSITION POINT: CHALLENGES AND OPPORTUNITIES

The transition from the years spent in medical school and clinical internship to those of our chosen field of radiology often poses a number of challenges, several of which are somewhat unexpected. For many of us, the most difficult aspect of this transition was leaving “hands on” medicine that, until now, constituted the bulk of our clinical experience. As an intern who was closely involved in obtaining information from the patient and their family, discussing the specifics of the case with a team to formulate a diagnosis and subsequently begin proper treatment, the sudden significant reduction in patient contact as a radiology resident can be a bit startling. This abrupt apparent exclusion from the decision making process and direct care of the patient is difficult; to go from being an intern who was often the main point of contact between the patient and the care giving team to operating largely behind the scenes as an imaging consultant with a
markedly abridged version of the patient’s presentation can be unsettling.

As a radiologist, one of your primary responsibilities will be to advise other physicians on how to best utilize our services and request examinations that will answer their clinical questions. As previously mentioned, on this side of the road patient information can be scarce. Unfortunately, more often than not, the first imaging examination has already been performed and is on your PACS station for interpretation before you ever have an opportunity to talk with the referring team about their clinical concerns and the optimal study for their patient. This rather common course of events has resulted in an increased number of unnecessary examinations, wasted valuable resources, and higher doses of radiation being imparted to our patients. This quandary of increasing utilization and subsequently rising radiation doses has been featured in the media, is the subject of much debate, and has
led to radiology endorsed actions such as the ‘Image Gently’ campaign.

While there are several instances where we come into direct contact with patients such as mammography, vascular and interventional radiology, and fluoroscopic procedures, this is still a significant reduction from our prior experience. Despite our diminished direct contact with our patients, as radiologists we continue to play an integral role in their care. Though we may not personally deliver the news to our patients, we often are the physicians who diagnose their diseases with multimodality imaging. Many times, it is here that our involvement ends. However, in other cases we continue to play a role in their care, monitoring response to treatment, further narrowing down differentials, and providing our expert opinion at multi-departmental conferences. Some may view this change from our prior role as a loss of autonomy in regards to the decision making process. The truth is we play a crucial role in the diagnostic process.
and at times the subsequent treatment; we therefore have a significant impact on patient care that is both rewarding and the reason we became physicians in the first place.

Another unforeseen issue comes from patients, clinicians, and even our own friends and family. When people hear the word “radiologist”, many have an unclear idea of what this entails, thinking ‘they are the ones who take the pictures, right?’ Even our fellow physicians can forget that as radiologists, we are the expert authority when it comes to the various imaging modalities. As fully trained physicians in a competitive specialty this misconception of our capabilities can be quite irritating, to put it mildly. However, we must take it upon ourselves to dispel these misconceptions about our profession and ourselves. We must step out from behind the curtain and become increasingly visible at our institutions, educating people about our role in patient care and expertise with imaging. When imaging is presented at various
conferences we should be the physicians discussing the findings. We should support initiatives, such as the American College of Radiology’s “Face of Radiology” campaign, that strive to educate people on what exactly radiologists do and why our education, training, skills, and experience are essential to providing a high quality of patient care.

We are medical care providers with, in essence, two sets of consumers: our patients themselves, and the clinicians who referred them to us. As radiologists, we have highly specialized knowledge of a field that is becoming increasingly accessible to other physicians. The question then becomes, how do we separate ourselves from those self-referring physicians less qualified to interpret diagnostic imaging, particularly while we are consultants? As previously mentioned this requires us to become increasingly visible and educate the public and our peers. We need to maintain the highest understanding of the technology utilized in image acquisition and
display as well as the issues of radiation dosage. By making ourselves as accessible as our images and having a thorough understanding of the associated technology and radiation dosage, we become as indispensable in patient care as the images we interpret.

Despite these and other issues that come up during your transition into radiology or throughout your career, rest assured that you are part of a truly remarkable field. Radiology is a challenging, multifaceted discipline which one can easily spend a lifetime learning. As many other disciplines in medicine, this is and will likely remain a field in transition. If we are to have a part in shaping the future of our chosen specialty, it is up to us, our generation of radiologists, to speak up, become involved, and strive to appropriately adapt to the changing environment, never forgetting our duty to the patients we image.
2: GET INVOLVED, TAKE ACTION

Radiology is a diverse field, encompassing the gamut of human anatomy and physiology. However, a solid understanding of the medical and imaging sciences is no longer enough to be a good radiologist. Our field continues to change rapidly. More imaging is being performed by clinicians and hotly debated topics such as self-referral and reimbursement are taking center stage. These issues will shape our future practice models in ways no one can currently predict.

We must all educate ourselves on these issues to remain competitive as our field continues to evolve. One of the best ways to do this is to become involved in organized medicine. While this takes time away from conventional training and clinical practice, understanding the business and political climate surrounding our specialty should be considered an integral part of a well-rounded education.
Currently, the primary organization dedicated to political advocacy for radiologists is the American College of Radiology Association (ACRA). The ACRA shares the membership of the American College of Radiology (ACR). While the ACRA and the ACR are separate entities from a legal and corporate standpoint, they share the goal of advancing the science and practice of radiology. This includes political monitoring and lobbying by the ACRA’s political action committee, RADPAC. The ACR strives to advance our field through other activities, including physician and patient education as well as accreditation and quality assurance.

As the field of imaging continues to evolve, we must adapt with it in order to preserve our ability to provide quality patient care and continue to be a viable and strong specialty. Moreover, we cannot simply react to the changes around us. Government and insurance companies are writing new rules for reimbursement and standards of care every
day; we can either be subject to them, or we can help write the rules ourselves.

Again, the best way to learn about the issues that will become more and more important as you advance in your career is to get involved in organized radiology on a local, regional and national level. The more of us become involved, the stronger our voice will be.

In the remainder of this chapter, a large number of organizations within the fields of medicine and radiology are described. There are also many city and state-based associations available, depending upon your particular locale. The specific goals of the organizations are varied, but all help to foster a sense of community among physicians and medical professionals. Additionally, many of these organizations devote time and funding to the education of physicians on the issues that shape the quality of medical care as well as the financial and medicolegal climate. As a resident physician, you are afforded free
membership in many of these organizations. This is a wonderful chance to learn about their activities, find one or more that appeal to you and **GET INVOLVED**.

**The American Board of Radiology (ABR)**

“The mission of The American Board of Radiology (ABR) is to serve patients, the public, and the medical profession by certifying that its diplomats have acquired, demonstrated, and maintained a requisite standard of knowledge, skill and understanding essential to the practice of Diagnostic Radiology, Radiation Oncology and Radiologic Physics.” The ABR is responsible for board certification and maintenance of certification for radiology.

**Web site:** [www.theabr.org](http://www.theabr.org)

**The American College of Radiology (ACR)**

The 32,000 members of the American College of Radiology (ACR) include radiologists, radiation oncologists, medical physicists, interventional radiologists and nuclear medicine physicians. For over three quarters
of a century, the ACR has devoted its resources to making imaging safe, effective and accessible to those who need it. The mission of the ACR is to serve patients and society by maximizing the value of radiology, radiation oncology, interventional radiology, nuclear medicine and medical physics by advancing the science of radiology, improving the quality of patient care, positively influencing the socio-economics of the practice of radiology, providing continuing education for radiology and allied health professions and conducting research for the future of radiology. The College also supports its members as they adapt to a rapidly changing health care environment. To best represent the field of radiology, the ACR works with many other organizations and entities: the Congress, federal and state agencies, other professional societies, and a variety of medical providers, corporations, and suppliers.

Publications by the College include The Journal of the American College of Radiology
(JACR) and the ACR Bulletin. Headquarters are located in Reston, Virginia with offices in Philadelphia and Washington, DC. The ACR hosts an annual meeting in May in Washington, DC.

**Web site:** [www.acr.org](http://www.acr.org)

**The American College of Radiology Association (ACRA)**

This organization shares its membership with the ACR and as a 501(c)6, handles all government relations and economic issues. While the ACRA and the ACR are separate entities from a legal and corporate standpoint they share the goal of advancing the science and practice of radiology. This includes political monitoring and lobbying activities by the ACRA’s political action committee, RADPAC ([www.radpac.org](http://www.radpac.org)).

**The American Medical Association (AMA)**

The mission of the American Medical Association (AMA) is to promote the art and science of medicine and the betterment of public health. The AMA’s vision is to be an
essential part of the professional life of every physician and to focus on the core values of leadership, excellence and integrity and ethical behavior. The American Medical Association helps doctors help patients by uniting physicians nationwide to work on the most important professional and public health issues.”

The AMA is the largest association of physicians and medical students in the United States. AMA Publications include the Journal of the American Medical Association (JAMA), American Medical News, Virtual Mentor, Disaster Medicine and Public Health, and Preparedness. Headquarters are located in Chicago, IL. The AMA hosts multiple meetings each year, with one of its major meetings in June.

**Web site:** [www.ama-assn.org](http://www.ama-assn.org)

**The American Roentgen Ray Society**

**(ARRS)**
The American Roentgen Ray Society (ARRS), founded in 1900, is the first and oldest radiology society in the United States.

The society is dedicated to the goal of the advancement of medicine through the science of radiology and its allied sciences. The goal of the ARRS is maintained through an annual scientific and educational meeting and through publication of the *American Journal of Roentgenology*.

Publications of the society include the *American Journal of Roentgenology (AJR)* and the ARRS *InPractice Magazine*. Headquarters are located in Reston, VA. The AARS hosts an annual meeting in April/May.

**Web site:**  [www.arrs.org](http://www.arrs.org)

**The Association of University Radiologists (AUR)**

The Association of University Radiologists (AUR) consists of over 3,000 academic radiologists, residents, and fellows. The
The purpose of the Association of University Radiologists is to encourage excellence in radiological laboratory and clinical investigation, teaching and clinical practice; to stimulate an interest in academic radiology as a medical career; to advance radiology as a medical science; and to represent academic radiology at a national level.”

Publications include the journal *Academic Radiology*. Headquarters are located in Oak Brook, IL. The AUR hosts an annual meeting in the spring.

**Web site:** [www.aur.org](http://www.aur.org)

**The Nuclear Regulatory Commission (NRC)**
The Nuclear Regulatory Commission (NRC) is a United States government agency. It was established by the Energy Reorganization Act in 1974 and took over the role of overseeing nuclear energy and safety matters from the Atomic Energy Commission (AEC). The NRC oversees reactor safety, reactor licensing and renewal, material safety and licensing, and
waste management. The purpose of the NRC is to regulate civilian use of byproduct, source and special nuclear materials to ensure protection of public health and safety, promote common defense and security, and protect the environment.

The NRC is headquartered in Rockville, MD.

**Web site:** [www.nrc.gov](http://www.nrc.gov)

**The Radiological Society of North America (RSNA)**

The mission of the Radiological Society of North America (RSNA) is to promote and develop the highest standards of radiology and related sciences through education and research. The Society seeks to provide radiologists and allied health scientists with educational programs and materials of the highest quality and to constantly improve the content and value of these educational activities. The Society seeks to promote research in all aspects of radiology and related sciences, including basic clinical research in the promotion of quality healthcare. The
Society seeks to foster closer fellowship among all radiologists and greater cooperation among radiologists and members of other branches of medicine and allied healthcare professionals.
RSNA is headquartered in Oak Brook, Ill., and hosts an annual meeting in Chicago in late November.

Web site:  www.rsna.org

A selection of specialty organizations follows.

The American Alliance of Academic Chief Residents in Radiology (A³CR²)
The A³CR² is an organization of academic radiology chief residents. The mission of the organization is to encourage residents and other trainees’ in academic pursuits, to involve the leadership of residency programs with the leaders of academic radiology, to encourage scientific inquiry among residents and to provide a voice for academic radiology residents in the affairs of organized radiology. The organization supports the discussion of
common problems in residency training, interactions with the ABR, the ACR, and experience for residents in a number of types of scholarly activities.

**Web site:** [www.aur.org/A3CR2/](http://www.aur.org/A3CR2/)

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**The American Association of Women Radiologists (AAWR)**

The American Association of Women Radiologists (AAWR) is comprised of approximately 2,100 members and serves to provide a forum for issues unique to women in radiology, radiation oncology, and related professions. The organization also sponsors programs that facilitate networking among members and other professionals as well as promoting opportunities for women. The AAWR Research and Education Foundation provides Professional Leadership Awards and Research Grants to AAWR members. Other activities include lectures at AAWR luncheons, an instructional course at the annual American Roentgen Ray Society (ARRS) meeting, and a refresher course at the
Radiological Society of North America (RSNA) annual meeting.

The AAWR does not host its own annual meeting, but does have representation at other major national meetings.

**Web site:**  [www.aawr.org](http://www.aawr.org)

**The American College of Radiation Oncology (ACRO)**

The American College of Radiation Oncology (ACRO) is a professional society established to ensure the highest quality care for radiation therapy patients and promote success in the practice of radiation oncology through education, responsible socioeconomic advocacy, and integration of science and technology into clinical practice. The college offers 3 scholarships annually for residents to travel to another residency program to receive specialized training unavailable at their home institution. They also offer annual resident scholarships for medical informatics and palliative medicine. ACRO hosts an annual
meeting in February. Fifteen travel awards are available to second, third, or fourth year radiation oncology residents to attend the annual meeting.

**Web site:** [www.acro.org](http://www.acro.org)

**The American Society of Emergency Radiology (ASER)**

The American Society of Emergency Radiology (ASER) is comprised of emergency radiologists with the goal of advancing the quality of diagnosis and treatment of acutely ill or injured patients by means of medical imaging, and to enhance teaching and research in Emergency Radiology.

The society publishes the journal *Emergency Radiology*. Headquarters are located in Houston, TX. ASER hosts an annual meeting in September/October.

**Web site:** [www.erad.org](http://www.erad.org)
The American Society of Neuroradiology (ASNAR)
The American Society of Neuroradiology (ASNAR) is a professional membership society comprised of over 3,000 physicians specializing in the field of neuroradiology.

Publications of the society include the *American Journal of Neuroradiology (AJNR)*. Headquarters are located in Oak Brook, IL. ASNAR hosts an annual meeting in April/May.

**Web site:**  [www.asnr.org](http://www.asnr.org)

The American Society for Radiation Oncology (ASTRO)
The American Society for Radiation Oncology (ASTRO) is comprised of over 9,000 members including radiation oncologists, radiation oncology nurses, medical physicists, radiation therapists, dosimetrists, and biologists. The society’s mission is the advancement of the field of radiation oncology by promoting excellence in patient care, promoting and disseminating research, and representing
radiation oncology in a rapidly evolving healthcare environment. ASTRO also fosters collaboration between medical radiation oncologists and the larger medical community, and works closely with the media and patient advocacy organizations to keep the public informed about radiation therapy as a safe and effective treatment option.

ASTRO sponsors year-round educational courses and publishes the International Journal of Radiation Oncology*Biology*Physics (aka the Red Journal). Headquarters are located in Fairfax, VA. ASTRO hosts multiple meetings each year, with an annual meeting in the fall.

**Web site:** [www.astro.org](http://www.astro.org)

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**The Society for Advancement in Women's Imaging (SAWI)**

The Society for Advancement in Women’s Imaging (SAWI) is an organization formed with the intention of providing a forum to promote
a sub-specialty within diagnostic radiology devoted to the diagnostics and treatment of diseases and conditions unique to women. The Society supports research, residency and fellowship training pertaining to all aspects of women’s imaging. SAWI also sponsors educational and scientific meetings that focus on women's imaging.

Publications of the society include the *Journal of Women’s Imaging*. Headquarters are located in Schereville, IN. SAWI hosts a symposium in conjunction with the Chicago International Breast Course in September.

**Web site:** [www.sawi.org](http://www.sawi.org)

**The Society of Breast Imaging (SBI)**
The Society of Breast Imaging (SBI) is a professional medical organization dedicated to improving the practice of breast imaging, enhancing the quality of breast imaging education, fostering research in breast imaging, and providing a forum for exchange of ideas among those involved in breast
imaging. The SBI provides an annual SBI Biennial Post-graduate Course for CME. The 2007 course was the largest dedicated breast imaging conference in the world.

Headquarters are located in Reston, VA. The SBI does not host an annual meeting, but fellows’ meetings are held annually at RSNA and the SBI Biennial Post-graduate Course.

Website: www.sbi-online.org

**The Society of Gastrointestinal Radiologists (SGR)**

The Society of Gastrointestinal Radiologists (SGR) is a professional society with the purpose of fostering advances in the fields of diagnostic, interventional, gastrointestinal, and abdominal radiology, providing a forum for the exchange of knowledge pertaining to research, practice, and education in gastrointestinal and abdominal radiology, and stimulating investigation and teaching in the methods of preventing and treating diseases.
The SGR has established lectureships, scholarships, foundations, and recognition awards in gastrointestinal and abdominal radiology, and also provides sponsorships for a variety of educational activities including CME activities.

Headquarters are located in Houston, TX. The SGR hosts an annual meeting in March.

**Web site:** [www.sgr.org](http://www.sgr.org)

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**The Society of Interventional Radiology (SIR)**

The Society of Interventional Radiology (SIR) is a national organization of physicians, scientists, and allied health professionals dedicated to improving public health through minimally invasive, image-guided therapeutic interventions.

The society publishes the *Journal of Vascular and Interventional Radiology* (*JVIR*). Headquarters are located in Fairfax, VA. The SIR hosts an annual meeting in March and
offers resident-in-training scholarships to first and second year radiology residents to attend the meeting.

**Web site:**  [www.sirweb.org](http://www.sirweb.org)

**The Society of NeuroInterventional Surgery (SNIS)**

The Society of NeuroInterventional Surgery (SNIS), formerly the American Society of Interventional and Therapeutic Neuroradiology (ASITN), is comprised of neurointerventional radiologists with the mission of promoting excellence in patient care, providing education, supporting research, influencing healthcare policy, and fostering growth in the specialty.

The SNIS has announced plans to launch a new journal, the *Journal of NeuroInterventional Surgery (JNIS)* in 2009. Headquarters are located in Fairfax, VA. The SNIS hosts an annual meeting in July.

**Web site:**  [www.snisonline.org](http://www.snisonline.org)

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SNM

The SNM is an international scientific and professional organization with 16,000 members comprised of physicians, technologists, and scientists specializing in the research and practice of nuclear medicine. The mission of the society is to promote the science, technology, and practical application of nuclear medicine. The society publishes journals, newsletters, and books, as well as sponsors international meetings and workshops designed to increase the competencies of nuclear medicine practitioners and to promote new advances in the science of nuclear medicine.

Publications of the society include the *Journal of Nuclear Medicine* and the *Journal of Nuclear Medicine Technology*. Headquarters are located in Reston, VA. The SNM hosts an annual meeting in October and a Mid-Winter Educational Symposium.

**Web site:**  [www.snm.org](http://www.snm.org)

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The Society of Radiologists in Ultrasound (SRU)
The Society of Radiologists in Ultrasound (SRU) is comprised of radiologists specializing in ultrasound and seeks to advance ultrasound in radiology. The SRU sponsors an annual Member-in-Training Research Award, which is given to the SRU in-training member (resident or fellow) who submits the best paper on original research in ultrasound. The Ultrasound Challenge is a feature on the SRU website for resident and fellow education.

The society publishes the journal *Ultrasound Quarterly*. Headquarters are located in Reston, VA. The SRU hosts an annual meeting in October.
Website: [www.sru.org](http://www.sru.org)

The Society of Skeletal Radiology (SSR)
The Society of Skeletal Radiology (SSR) is comprised of musculoskeletal radiologists with the mission to encourage and support the

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development of expertise in the subspecialty of musculoskeletal radiology. Headquarters are located in Schaumburg, IL. The SSR hosts an annual meeting in March.

**Web site:**  [www.skeletalrad.org](http://www.skeletalrad.org)

### The Society of Thoracic Radiology (STR)

The Society of Thoracic Radiology (STR) is an organization of radiologists interested in and dedicated to cardiopulmonary radiology. The mission of the society is to promote and foster excellence in cardiothoracic imaging and clinical care through research and education.

Publications of the society include the *Journal of Thoracic Imaging*. Headquarters are located in Rochester, MN. The STR hosts an annual meeting in May/June

**Web site:**  [www.thoracicrad.org](http://www.thoracicrad.org)

### The Society of Uroradiology (SUR)

The Society of Uroradiology (SUR) is comprised of radiologists specialized in uroradiology. The organization seeks to
promote interest in the advancement of urinary tract and gynecological imaging. The SUR also promotes the integration of multiple imaging modalities including conventional radiography, sonography, CT, MRI, nuclear medicine, and interventional procedures in the study of normal and abnormal processes of the urinary tract and pelvis. The SUR gives multiple awards for research and achievement in the field of uroradiology.

Headquarters are located in Houston, TX. The SUR hosts an annual meeting in March.

**Web site:** [www.uroradiology.org](http://www.uroradiology.org)

**Other Notable Societies and Organizations affiliated with Radiology**

- The Association of Program Directors in Radiology (APDR) [www.apdr.org](http://www.apdr.org)
- The European Society of Radiology (ESR) [www.myesr.org](http://www.myesr.org)
- The International Society for Magnetic Resonance in Medicine (ISMRM) [www.ismrm.org](http://www.ismrm.org)
- The Society for Pediatric Radiology
  [www.pedrad.org](http://www.pedrad.org)
- The American Institute of Ultrasound in Medicine [www.aium.org](http://www.aium.org)
- The Academy of Molecular Imaging [www.ami-imaging.org](http://www.ami-imaging.org)
- The Academy of Radiology Research [www.acadrad.org](http://www.acadrad.org)
- The International Society of Radiology [www.isradiology.org](http://www.isradiology.org)
3: INTRODUCTION TO RESIDENT ROTATIONS

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 likely 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” typically includes: gastrointestinal (GI) fluoroscopy, genitourinary (GU) fluoroscopy, computed tomography (CT) of the abdomen and pelvis, chest, abdominal, and pelvic magnetic resonance imaging (MRI), +/- cardiac imaging and +/- chest CT studies. The extent of what is covered on each rotation may differ and each of the above topics may be split up separately. For example, one department may
have a rotation specifically for MRI and therefore body MRI would be read separately rather than by the body section. Departments may also separate schedules into a GI rotation and a GU rotation or fluoroscopic specific rotation, etc.

**Fluoroscopy:** The volume of fluoroscopic studies will vary by institution, depending on the clinical teams. Studies include cystograms, retrograde urethrograms (RUGs), intravenous pylegrams (also known as IVUs), barium enemas, upper GI series, esophagrams, loopograms, etc. The technical component of these examinations can be learned quickly by most first years either under the guidance of a more senior resident or an attending. The more difficult task lies in interpreting the images you have obtained. Each morning, prepare a list of the patients for the day and look up his/her history and old studies (including old fluoroscopic studies, CT, etc) so you are prepared for each examination. At the beginning of your
training, the fluoroscopic technologists often know more than you do, so do not be afraid to ask them for help.

Fluoroscopic studies use oral or intravenous contrast to opacify the gastrointestinal or genitourinary system, respectively. Also, contrast material can be administered retrograde, such as in a barium enema or cystogram.

Contrast options for fluoroscopic studies:

**Barium:** Common oral contrast used for healthy patients and outpatients. Barium is available in “thick or thin” consistencies. Thick barium is commonly used in upper GI evaluations and colonography, and is frequently combined with effervescent crystals or air, respectively. If there is concern for GI perforation below the diaphragm, then consider using a water-soluble agent.
**Gastrografin/ Hypaque/ Omnipaque:**
Water-soluble oral contrast agents commonly used for inpatients, sick patients and post-operative patients. Should NOT be used in patients at risk for aspiration. Gastrografin is a hypertonic solution and if aspirated, can lead to flash pulmonary edema.

**Conray/ Cystoconray-II:** Intravenous contrast typically used for renal examinations. This can also be instilled retrograde into the urethra and bladder.

**Computed Tomography:** There are many different types of computed tomography (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-contrasted CT examinations are performed primarily for renal stone evaluation and in patients who cannot receive IV contrast because of poor renal function or a history of contrast reaction. However, they also may be utilized to conduct rapid studies to look for retroperitoneal hemorrhage following cardiac catheritization.

Single-phase intravenous contrast examinations can be performed for reasons including 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. For example, an early arterial contrast phase is obtained when contrast is in the aorta and main abdominal arteries. Selected combinations of these techniques are used for evaluation of renal, hepatic and abdominal pathology. CT angiography uses some of these phases for
evaluation of the thoracic or abdominal vasculature.

Timing of the described phases may vary 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 5 for more
information regarding contrast administration, reactions and treatments.

Few absolute contraindications to oral contrast exist (high grade SBO, inability to drink), and hence it should be administered for almost all abdomen/pelvis CT evaluations if the patient can tolerate. One can choose between two general categories of oral contrast depending on the pathology being evaluated, positive which is bright on CT (Barium, Hypaque, Gastrografin, Omnipaque) and negative which is dark on CT (Volumen or Water).

As a first year, you may not be asked to protocol CT exams, but you want to start doing this as soon as possible. It will help you learn the indications for all types of exams and when to use both intravenous and oral contrasts.

**BREAST IMAGING**
Breast Imaging includes mammograms (both screening and diagnostic), ultrasound, biopsies, MRI and ductograms. Screening mammograms are examinations performed on women 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 an abnormal finding was identified on 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 ultrasound may be performed by an ultrasonographer or by a physician (this differs by institution). 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 is becoming more popular and may be performed for patients at high risk for breast cancer, women with dense breast, 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 woman 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: the life support devices (endotracheal tube (ETT), central lines, etc), pulmonary edema, airspace opacities, and pneumothorax. You will quickly learn these basics. The advanced skills (picking up shunt vasculature and diagnosing cardiac anomalies or picking up subtle nodules) will come with time. Learn how to read both the 2-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).

The chest service may read regular and high-resolution chest CT. Chest CT examinations can be performed for many reasons (pneumonia, malignancy, etc); a high-resolution chest CT is ordered for evaluation of the lung parenchyma with thin slices, looking for interstitial disease, etc. You should also become comfortable with studies for pulmonary embolus, as these are common studies read on call. Depending on the department, you may start reading these CT examinations early in your training, or you may wait for your second or third rotation.

**INTERVENTIONAL/VASCULAR PROCEDURES**

Image-guided procedures include a variety of examinations and these may be imbedded into the individual rotations that cover each body part or may be grouped together. These include CT-guided, ultrasound-guided or
fluoroscopic-guided procedures. Although these rotations can vary greatly, many key concepts apply to all of them.

The patient will need certain laboratory values checked--INR below and platelets above your institutional threshold value. 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 will be done under some kind of sedation (which will vary by institution). To receive both pain medication and sedation, the patient will need to be NPO for at least 6 hours (this may vary, so please check your institution’s policy) and be assessed for tolerance of conscious sedation. It is possible at times to just administer pain medication without sedation if the patient has eaten, depending on the procedure, but again, check with your institution. For some of these examinations, the patient will be receiving intravenous (and
intra-arterial) contrast, so an acceptable creatinine level should be obtained and an inquiry into any contrast allergy should be made.

**MUSCULOSKELETAL IMAGING**

Musculoskeletal (MSK) radiology includes radiographs (x-rays), CT, MRI and sometimes ultrasound, depending on the institution. Mainly bone radiographs are for trauma (fractures/dislocations), arthritis, postsurgical films, metabolic diseases, tumors and sports injuries. As a first-year resident, focus first on the radiograph, trying to understand and correctly diagnose many musculoskeletal processes, especially trying to master these skills for call. Try to learn how to accurately describe fractures, such as angulations, displacement, and types of fractures (transverse, comminuted, etc). Also, postsurgical musculoskeletal films can be complicated but are important when looking for hardware failures, such as loosening, infection, incorrect pin/nail placement and
change in position of nail/pin placement. For follow-up or complicated post-surgical indications, older comparison examinations are extremely useful.

After mastering the plain film, you can start to learn cross-sectional imaging: CT and MRI. CT and MRI are performed for many reasons, including evaluation of fractures, infection, malignancy, and sport injuries.

**NEUROLOGICAL IMAGING**

Neuroradiology consists of CT and MRI. CT examinations may include images of the brain, face, temporal bone, sinuses, neck or spine. MRI can evaluate similar body parts while providing greater detail especially with regards to the pituitary gland and cranial nerves. Also, both CT and MRI can perform angiographic studies for evaluation of the cervical and intracranial vasculature (referred to as CTA and MRA, respectively). One of the first things to learn is brain anatomy. For most of us, it has been some time since
neuroanatomy class, and relearning anatomy is essential. As you begin your rotation, focus first on CT. Most head CT is performed without intravenous contrast. If there is a history of intracranial mass or concern for infection, intravenous contrast may be administered. Learn basic pathologies such as subarachnoid hemorrhage, epidural and subdural hematoma, hemorrhagic and ischemic stroke (and associated findings such as midline shift, mass effect, etc) and tumor identification. After you become comfortable with CT, start looking at MRI. Invasive procedures, such as conventional angiography and spine interventions, may also be performed by the neuroradiology services. Fluoroscopy-guided lumbar punctures and myelography may 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.

The premise of nuclear examinations is that the body is imaged from the inside out. The radiopharmaceutical is administered to the patient (orally or intravenously) and travels to the particular tissue to which that tracer localizes. For example, Tc-99m methylene diphosphonate (MDP) is a bone agent that is chemiabsorbed to bone. The administered radiopharmaceutical emits radiation and the nuclear medicine camera (SPECT camera, for example) images the distribution of the material in the body. If additional images are needed, no additional radiation is given, because the radiopharmaceutical is already 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.

Cardiovascular nuclear imaging is also similar and is performed for evaluation of cardiac ischemia, infarct, viability, and ejection fraction. Most of cardiac imaging involves two steps-rest images and stress images. The patient can be stressed by exercise or by medication. At some institutions, it is the job of the resident to perform the examination (stressing the patient) while other hospitals have nurse practitioners/physician assistants
to do this. This may also be performed by the cardiology service.

**PEDIATRIC IMAGING**

Pediatric radiology involves radiographs (chest, bone, and abdomen), CT, ultrasound, fluoroscopy, MRI and sometimes neuroradiology. It will vary depending on how your program divides things up.

There are many types of radiographs performed on children, especially if you are at a hospital that has a pediatric intensive care unit. Learn the different pulmonary and abdominal processes that you will see in neonates and newborn babies. Another important topic to master is life support devices used in the neonatal intensive care unit (NICU), which are different from adult patients (mainly umbilical venous and arterial catheters).

Ultrasound is a first-line tool for pediatric imaging because no radiation is imparted. CT
and MRI are also performed every day. History is a key piece of information that should be obtained for all pediatric patients. For CT and MRI, you may be asked to protocol the studies each day. Ask your upper level resident or attending for help if you have questions, as the 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 at most institutions 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. At the beginning of the day, investigate the history for each patient on the schedule.
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 deep venous thrombosis examinations, fetal surveys, pelvic sonograms and abdominal Doppler studies. At some institutions, there are dedicated ultrasonographers who perform the examination; at other hospitals, the resident and attending physicians perform the ultrasound examinations, with residents performing such exams after hours. Try to perform the examination yourself as much as possible and do not be afraid to ask the ultrasonographers for help. Even if you have skilled ultrasonographers, there will be times when you will have to scan a complex case...
yourself in order to fully understand the anatomy.

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).

Sonographic images are at first intimidating to interpret as the anatomy is not presented as clearly as on other modalities. However with time, ultrasound will become easier to interpret.
4: 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 “As Low As Reasonably Achievable”. As a general principle, this means that radiation exposure should be limited to only what is necessary to achieve an appropriate diagnostic study. Examinations requiring the use of ionizing radiation are necessary in many circumstances and aid in both the diagnosis and treatment of many diseases. However, no procedure in medicine is without risk.

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 the radiation will have and uses a weighting factor. The equivalent
dose gives an approximate indication of the potential harm from ionizing radiation. It is only an approximation. 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 of “1” is used for most calculations.

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 favored.

1 Sv = 100 rem
1 Gy = 100 rad

BACKGROUND RADIATION

We are all exposed to background radiation in our daily life. The average amount of background radiation exposure in the U.S. 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).

Table 1:

<table>
<thead>
<tr>
<th>Background Radiation Source</th>
<th>Effective Radiation Dose</th>
</tr>
</thead>
<tbody>
<tr>
<td>Radon</td>
<td>2 mSv/yr</td>
</tr>
<tr>
<td>Smoking</td>
<td>2.8 mSv/yr to the lungs</td>
</tr>
<tr>
<td>Cross country flight</td>
<td>0.01 mSv each way</td>
</tr>
<tr>
<td>2 wk vacation in mountain area</td>
<td>0.03 mSv</td>
</tr>
<tr>
<td>Nuclear weapons testing</td>
<td>0.05 mSv/yr</td>
</tr>
<tr>
<td>Living in a brick home</td>
<td>0.35 mSv/yr</td>
</tr>
<tr>
<td>Luminous radium dial watch</td>
<td>36 mSv/yr to the wrist</td>
</tr>
<tr>
<td>Procedure</td>
<td>Average Adult Effective Radiation Dose</td>
</tr>
<tr>
<td>------------------------------------------------</td>
<td>---------------------------------------</td>
</tr>
<tr>
<td>CT Abdomen and Pelvis</td>
<td>7-10 mSv</td>
</tr>
<tr>
<td>CT Head</td>
<td>2 mSv</td>
</tr>
<tr>
<td>Chest Radiograph</td>
<td>0.1 mSv</td>
</tr>
<tr>
<td>CT thoracic/lumbar spine</td>
<td>10 mSv</td>
</tr>
<tr>
<td>Lumbar Spine AP Radiograph</td>
<td>2 mSv</td>
</tr>
<tr>
<td>Mammography per view</td>
<td>0.2 mSv</td>
</tr>
<tr>
<td>Bone Density Exam (DEXA)</td>
<td>0.01 mSv</td>
</tr>
</tbody>
</table>

Table 2:

Brightly glazed ceramic tableware (uranium in glaze) | 5-24 mSv/yr to the hands
Average medical exposure per US resident | 2.4 mSv/yr, (60% from CT)
Living in Denver | 6 mSv/yr

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<table>
<thead>
<tr>
<th>Procedure</th>
<th>Radiation Dose</th>
<th>Latency Period</th>
</tr>
</thead>
<tbody>
<tr>
<td>Barium Enema</td>
<td>8 mSv</td>
<td>3 years</td>
</tr>
<tr>
<td>CT chest PE protocol</td>
<td>15 mSv</td>
<td>5 years</td>
</tr>
<tr>
<td>3 phase liver protocol CT</td>
<td>15 mSv</td>
<td>5 years</td>
</tr>
</tbody>
</table>

**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 1 in 1000 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 1000 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 and deterministic. Deterministic effects of radiation are characterized by a threshold dose; below a certain dose, the effect does not occur. The severity of deterministic effects increases with the dose. Examples include cataract induction, skin erythema and sterility. 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.

**RADIATION AND CHILDREN**

Children are especially vulnerable to ionizing radiation due to increased sensitivity of developing tissues and organs to radiation effects. A child’s remaining life expectancy is also longer than an adult’s, so time is an
additional factor. 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. That said, the overall risk with standard diagnostic radiology exams is very low, and the risk of morbidity and mortality from the disease being evaluated may be much higher than any radiation risk. We must be aware of the potential risks and strive to follow the ALARA principle. Specific pediatric parameters for CT must be in place and alternate imaging options should be considered. Children should be examined with ultrasound and non-ionizing radiation imaging when possible.

In January 2008, the Alliance for Radiation Safety in Pediatric Imaging, founded by the Society for Pediatric Radiology (SPR), the American College of Radiology (ACR), the American Society of Radiologic Technologists (ASRT) and the American Association of
Physicists in Medicine (AAPM) launched an “Image Gently” campaign to reduce the radiation dose used in pediatric computed tomography (CT) exams. As stated above, children are more sensitive to radiation received from imaging scans than adults and cumulative radiation could, over time, have adverse effects. As such, the Alliance and the Image Gently campaign urges providers to significantly reduce, or “child-size” the amount of radiation used, only scan when necessary and only the indicated region.

Table 3:

<table>
<thead>
<tr>
<th>Procedure</th>
<th>Estimated Effective Dose for a 5 year old child</th>
</tr>
</thead>
<tbody>
<tr>
<td>PA and Lat Chest Radiograph</td>
<td>0.02 mSv</td>
</tr>
<tr>
<td>AP and Lat Abdomen Radiograph</td>
<td>2.5 mSv</td>
</tr>
<tr>
<td>Voiding Cystourethrogram (VCUG)</td>
<td>1.6 mSv</td>
</tr>
<tr>
<td>Head CT</td>
<td>4 mSv</td>
</tr>
<tr>
<td>Chest CT</td>
<td>3 mSv</td>
</tr>
<tr>
<td>Abdomen CT</td>
<td>5 mSv</td>
</tr>
</tbody>
</table>
RADIATION AND PREGNANCY

Imaging the pregnant patient is a common clinical dilemma. You may 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 retardation 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. (Doses in standard diagnostic radiology do not often go over this limit.)

With the preimplanted 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 intrauterine 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 10 mGy 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.
Table 4: Maximum Estimated Fetal Dose (mGy) with Common Exams

<table>
<thead>
<tr>
<th>EXAM</th>
<th>VIEW</th>
<th>MEAN</th>
<th>MAXIMUM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chest</td>
<td>PA</td>
<td>&lt;0.1</td>
<td>&lt;0.1</td>
</tr>
<tr>
<td>Thoracic Spine</td>
<td>AP</td>
<td>&lt;0.1</td>
<td>0.03</td>
</tr>
<tr>
<td>Hip</td>
<td>Lat</td>
<td></td>
<td>0.5</td>
</tr>
<tr>
<td>Lumbar Spine</td>
<td>AP</td>
<td>7.5</td>
<td>40</td>
</tr>
<tr>
<td>Lumbar Spine</td>
<td>Lat</td>
<td>0.91</td>
<td>3.5</td>
</tr>
<tr>
<td>Pelvis</td>
<td>AP</td>
<td>3.4</td>
<td>22</td>
</tr>
<tr>
<td>CT Head</td>
<td></td>
<td></td>
<td>&lt;0.5</td>
</tr>
<tr>
<td>CT Chest</td>
<td></td>
<td></td>
<td>&lt;1</td>
</tr>
<tr>
<td>CT Abdomen</td>
<td></td>
<td></td>
<td>26</td>
</tr>
</tbody>
</table>

References:

http://www.acr.org/MainMenuCategories/media_room/FeaturedCategories/PressReleases/ImageGentlyCampaignGainsInternationalMomentum.aspx

http://dels.nas.edu/dels/rpt_briefs/beir_vii_final.pdf

http://www.perinatology.com/exposures/physical/xray.htm

http://www.radiologyinfo.org/en/safety
5: CONTRAST 101

INTRAVENOUS CONTRAST

According to the ACR Manual on Contrast Media, the administration of intravenous (IV) contrast for a radiological exam should be done for an appropriate indication. When utilized, the radiologist should use all available information to minimize the likelihood of a contrast reaction. Additionally, it is the radiologists’ responsibility to be prepared to treat a reaction if it occurs.

IV contrast comes in various forms. The most commonly used contrast agent (and most commonly used agent with CT imaging) is iodinated IV contrast. It is also used with conventional angiography and other interventional procedures. Gadolinium is the most common IV contrast used for MRI. Allergic reactions may occur with both types of contrast, but these occur at an exceeding lower rate for gadolinium in comparison with iodinated contrast. Both iodinated and gadolinium based agents can have adverse
effects in patients with impaired renal function. Additional intravenous contrast agents, such as carbon dioxide (angiography), iron oxide (MRI) and manganese (MRI) are also used in certain settings, but are not discussed here. It is the radiologists’ responsibility to stay informed on scientific advances in contrast agents as well as to stay current on adverse reactions related to the contrast agents their institutions are administering.

**IODINATED CONTRAST AGENTS**

Iodinated contrast agents can be characterized as ionic or nonionic agents. Ionic and nonionic contrast agents are further characterized as high-, low- and iso-osmolar contrast media (HOCM, LOCM and IOCM, respectively). The contrast agents most commonly used today are low osmolar and iso-osmolar iodinated contrast agents. Low osmolality agents have osmolality approximately twice that of human serum and iso-osmolality agents has osmolality similar to the human serum. Specifically, low-
osmolality **nonionic** monomers are the most common. There are multiple different makers of these agents and there are numerous choices. These agents are newer and most commonly used because they have less adverse reactions than their older counterparts. Iodinated contrast agents are excreted primarily through glomerular filtration and to a minimal degree via hepatic excretion, typically in renal failure patients.

Before administering intravenous contrast, the renal function should be assessed. If the patient has a history of renal disease further investigation may be needed to understand the need for the requested examination. The method of evaluation has been debated in scientific literature. The most commonly used indicators for renal disease are blood creatinine (Cr) level and glomerular filtration rate (GFR), both of which should be checked before the examination is performed.
At most institutions, guidelines for appropriate creatinine and GFR levels are as follows, but check your home institution’s policies and procedures for further information:

**Cr < 1.5 mg/dl:** Permissible and contrast can be given.

**Cr 1.5-2 OR 2.5 mg/dl:** Iso-osmolar contrast is warranted. If iso-osmolar contrast is not available, you may choose to not administer intravenous contrast.

**Cr > 2 OR 2.5 mg/dl:** You will need to discuss this with an attending. Usually, contrast will not be used.

**GFR <30 ml/min:** If the estimated GFR is less than <30 ml/min, contrast is typically avoided unless the benefits outweigh the risk. At some institutions, the patient must be consented before administering intravenous contrast if the GFR is below 30 ml/min.

**DIALYSIS:**
The primary exception to these guidelines is the dialysis patient, who can receive iodinated contrast regardless of the creatinine or GFR.
Essentially, additional renal injury is not a concern since the patient has already typically progressed to end stage renal disease. You may need to be concerned about the patient’s volume status, and at some institutions, patients must be dialyzed with 24 hours of receiving IV contrast. When in doubt, it may be helpful to direct the referring physician to a nephrologist who is familiar with the patient. Note, this concept does not apply to MRI contrast.

**CONTRAST REACTIONS**

If a patient reports an IV contrast reaction prior to 1985, it could not have been to a low-osmolar nonionic agent, as these were not available, and the risk of a reaction with a newer agent is very low. The history of a prior reaction from an older contrast agent is not a contraindication for use today.

IV iodinated contrast agents are very safe, but adverse reactions do occur. The risk of death from a contrast reaction is low and less than 1/130,000. There are two types of reactions to IV contrast agents. These include idiosyncratic
and nonidiosyncratic reactions.

**Idiosyncratic Reactions:**
Idiosyncratic reactions typically begin within 20 minutes of contrast injection. Presentations appear identical to an anaphylactic reaction, but since there is not an antigen-antibody response, these reactions are classified as “anaphylactoid” or “non-allergic anaphylactic”. Treatment is identical to treatments for an anaphylactic reaction.

Examples of these kinds of reactions include:

- Urticaria
- Pruritis
- Facial edema
- Bronchospasm
- Palpitations
- Tachycardia
- Bradycardia
- Pulmonary edema
- Life-threatening arrhythmias

A past history of previous reaction to an iodinated IV contrast agent puts the patient at increased risk for future reactions, but a reaction is not guaranteed with additional exposures. Approximately 60% of patients with a history of hives will have hives with repeat exposure. Patients with a history
of asthma and other allergies do have a slight increased risk of reaction over the general public. There is no documented cross-reaction between iodinated IV contrast and shellfish. If a patient reports a history of shellfish allergy, iodinated IV contrast is not contraindicated.

**Nonidiosyncratic reactions:**
Nonidiosyncratic reactions are considered a physiologic effect of the contrast media rather than a real contrast allergy and are mainly dose dependent. Intravenous contrast material causes heightened systemic parasympathetic activity and peripheral vessel dilatation.

Examples of these kinds of reactions include:
- Nausea, vomiting, diaphoresis
- Mental status changes
- Bradycardia
- Hypotension
- Vasovagal reaction

**TREATMENT OF CONTRAST REACTIONS**
Reactions vary widely depending on the severity and symptoms. The following is a quick reference for common reactions.

**Urticaria** – If asymptomatic, no
treatment is needed. With mild to moderate symptoms, treatment with Benadryl (25-50 mg oral (po) or IV) is appropriate. If symptoms are severe, one can add IV cimetidine or ranitidine in addition to Benadryl.

**Bronchospasm** – Mild symptoms should be treated with oxygen and inhaled albuterol or metaproterenol. Moderate symptoms should also be treated with subcutaneous epinephrine (0.03 cc of 1:1000 epinephrine). Severe symptoms should be treated with intravenous epinephrine (1 cc of 1:10,000 epinephrine).

**Laryngeal edema** – Treat initially with oxygen and subcutaneous epinephrine (0.03 cc of 1:1000 epinephrine). If symptoms are severe, IV epinephrine, Benadryl and cimetidine can be given. Patients may require intubation.

**Isolated hypotension** – Place the patient in Trendelenberg (head down, feet up) and administer IV fluids.

**Vasovagal reaction** – Place the patient in Trendelenberg, administer oxygen and IV fluids. If patient remains symptomatic with bradycardia, IV atropine can be administered.

For severe contrast reactions, including the
threat of impending airway loss or symptomatic hypotension, call a code (in a hospital setting) or 911 (in a clinical setting). Despite the high volume of patients passing through your radiology department, the physicians and support staff do not treat cardiopulmonary arrest as frequently as other physicians. Call for help BEFORE the situation becomes emergent.

**CONTRAST REACTION PROPHYLAXIS**

It has been shown that medication with corticosteroids with or without antihistamines prior to contrast injection does reduce the incidence of minor adverse reactions (urticaria, itching and mild wheezing) and is very safe. Prophylaxis has not been shown to decrease severe reactions. If prophylaxis is given, steroids must be started 12 hours prior to contrast injection and personnel must be available at the time of the exam to treat a reaction. The following are 2 examples of steroid prophylaxis. These protocols change depending on the institution, so please check
with your institutional policy. Two examples for adult patients are:

1. Methylprednisolone (Medrol®): 32mg by mouth 12 hours and 2 hours prior to contrast administration

2. Prednisone: 50 mg by mouth at 13 hours, 7 hours and 1 hour prior to exam, plus Diphenhydramine: 50 mg intravenously, intramuscularly, or by mouth 1 hour before contrast medium injection

One important point to remember is that steroids need to be given at least 6 hours prior to the injection of contrast media to have any effect, per ACR guidelines. Antihistimines can be added to prophylaxis regimens, especially when symptoms from previous reaction are slightly more severe.

**METFORMIN**

Patients taking metformin (a hypoglycemic agent used in treatment of diabetes) have a measurably increased risk of developing lactic acidosis following intravenous administration of iodinated contrast. Metformin should be
held for 48 hours following an examination with intravenous iodinated contrast, or according to your department’s guidelines.

**GADOLINIUM CONTRAST AGENTS**

MRI contrast agents, such as gadolinium, are administered for similar reasons that CT studies use iodinated contrast agents: tumor and parenchymal enhancement and differentiation, vascular evaluations, etc. The effect of gadolinium is based on magnetic susceptibility when the contrast is placed in a magnetic field (the MRI scanner). There are many different gadolinium based products. Agents may be dedicated for specific imaging (i.e. liver imaging). Gadolinium contrast is excreted mainly through glomerular filtration with minimal hepatobiliary excretion. Some newer agents have increased hepatobiliary excretion.

Studies with gadolinium-based agents and pregnancy have been inconclusive; therefore, contrast is generally not administered to
pregnant patients. There has not been a large well-controlled study on the effects to the embryo from gadolinium contrast. At this time, the ACR recommends the pregnant patient undergoing an MR examination provide informed consent to document that she understands the risks and benefits of the MRI procedure.

**CONTRAST INDUCED NEPHROPATHY**

Contrast induced nephropathy is renal failure following the administration of an iodinated contrast agent. It is defined as an elevation in serum creatinine that is more than 50% of the baseline level at 1-3 days after the contrast injection. The elevation in serum creatinine peaks at days 7-10 following injection and usually returns to baseline within 2 weeks. Very few people go on to develop long-term renal failure as a result of contrast induced nephropathy. Contrast induced nephropathy occurs in people with pre-existing renal insufficiency. Diabetics with renal disease are especially vulnerable.
The most important step to take in preventing contrast induced nephropathy is ensuring that patients at risk are well hydrated. Patients can do this at home by drinking several liters of liquids 12-24 hours before exam. IV hydration can also be performed. It should consist of 1cc normal saline (NS) per kg body weight per hour beginning 12 hours before exam and continuing for 2-12 hours after exam. IV hydration is superior to oral hydration. Sodium bicarbonate has also been used recently in lieu of NS. The use of bicarbonate remains controversial.

N-acetyl cysteine is also used by many in hopes of preventing contrast induced nephropathy, but research to date is inconclusive. It is thought to be protective secondary to its vasodilatation and free radical scavenger properties. It is safe, readily available and inexpensive. The dose is generally 600mg twice a day (BID) for 48 hours starting on the day of contrast
administration. Despite the lack of definitive data, many clinicians believe in this prophylaxis and the treatment is considered generally harmless.

**NEPHROGENIC SYSTEMIC FIBROSIS**

Nephrogenic systemic fibrosis (NSF) is a systemic disorder characterized by widespread tissue fibrosis. It was previously described as nephrogenic fibrosing dermopathy because of its dominant cutaneous findings. However, in recent years, the systemic findings of this disease have lead to the name change. The underlying cause of NSF has not been determined, but it occurs only in patients with renal disease and occurs after the administration of gadolinium-based intravenous contrast.

Early signs and symptoms are seen within 2 weeks after receiving a gadolinium injection and include extremity edema and swelling, myalgias and extremity weakness. Later signs and symptoms include skin fibrosis,
thickening and tightening, leaving some patients with contractures. The findings involve the lower extremities most commonly, followed by the upper extremities and torso. Systemic features may include fibrosis of the pericardium, myocardium, pleura, lungs, skeletal muscle, kidneys and dura.

**References:**


Morcos, SK and Cohan, RH. *New Techniques in Uroradiology*. 2006. 4

Siddiq NH. Contrast Medium Reactions, Recognition and Treatment. *Emedicine* 2/11/12008


www.radiologyinfo.org

Special thanks to Wayne Thompson, MS Medical Physicist University of TN Medical Center Knoxville
6: THE RADIOLOGIST’S REPORT AND DICTATIONS

One of the most harrowing experiences of a young radiologist’s first few days is the radiologist’s report. Consider your first day. You have reviewed your study with your attending. You scored a few points by noticing the missed rib fracture or made a great differential diagnosis for a ground glass opacity in the lung. Now the attending walks in and asks you to dictate the case. You think, “What am I supposed to say? How do I describe the finding? What sort of negatives do I include? Wait, what about the rest of the report? Which comparisons? Nobody provided history! What about the technique?”

This chapter will answer those questions. For the reader’s convenience the chapter is divided into two parts. The first part (*Section A: The Things You MUST Know*) will answer questions and provide information that you must know for your first year of residency. Read this section well before you begin your residency
and revisit it after you have a few dictations under your belt.

The second section *(Section B: The Things You SHOULD Know)* will cover items you should know and make for a more complete or appropriate report, but are not as crucial. You may incorporate and revisit this information throughout your residency, as some of the points are quite complex.

**SECTION A: THE THINGS YOU MUST KNOW**

**FORMAT**
The radiology report can be divided into 6 main sections:

1. Examination
2. Technique
3. History/Indication
4. Comparison
5. Findings
6. Impression

**EXAMINATION**
For now, the examination section of your report should include the following information:
1. Modality (CT, MRI, US, etc.)
2. Body part, if applicable (wrist, abdomen, head, etc.)
3. Use of contrast and route of administration
   a. Intravenous
   b. Intra-arterial
   c. Intrathecal
   d. Intraarticular
   e. Other (through salivary glands, nasolacrimal duct, other strange -ograms)
4. Use of guidance (for procedures)
   a. Fluoroscopic
   b. Mammographic
   c. Stereotactic
5. Whether you or the technologist created reformations or reconstructions (usually these are sagittal and coronal plane reformations or 3D reformations)

**Example**
Examination: CT abdomen and pelvis with and without intravenous contrast with 3D reformations

Sometimes the body part and route of contrast administration are implied by the procedure, but for now it will be safe to be redundant.

**Example**
Examination: Intrarectal barium enema evaluation of colon under fluoroscopy.
In the above example, the “intrarectal” and “evaluation of colon” is redundant because the CPT code (explained in the second part of this chapter) for barium enema implies those. However, “under fluoroscopy” is NOT always implied. ALWAYS mention the method of guidance.

Include your name AND your attending’s name somewhere in the report as mandated by your residency program. This automatically may be included in your report if you have a voice recognition system. Check with your program director or support staff.

**TECHNIQUE**

Under this section, you will describe the examination in detail (e.g., the thickness of your CT slices or reconstructed images, the exact anatomic upper and lower limits of your evaluation, the exact MR sequences and planes used). This technique section can be extremely detailed but in general it is used to
convey information to the other radiologists or clinicians about limitations (e.g., a certain MR sequence may not have been used) or extra work (e.g., different CT kernels used for reconstructions) that was required to perform the examination. Bottom line: If the examination is a departmental standard, then you do not need a technique section.

If you do something that is not standard for the study you may use this section to explain why (“No IV contrast used due to patient’s estimated GFR < 30 mL/min/1.73 m²” and “Additional SS T2W short axis sequence performed in 8 mm from base of heart to apex.”)

**Example**

Technique: Helically acquired 3 mm CT axial images were obtained from the thoracic inlet through the mid-abdomen without the intravenous administration of contrast.

**HISTORY**

Age, sex and primary clinical indication are a must. Sometimes the voice recognition system
will automatically add in age and sex. If you get a very detailed clinical history, add it to this section--you never know when the next time you will receive more than 5 words of clinical history. In general, detailed clinical histories allow you to shorten your differential diagnosis.

**Example**

History: 87-year old male presents with shortness of breath

**Example**

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

**COMPARISON**

Use comparisons liberally, especially across 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 from 3 years ago. When noting comparisons in your dictation, make sure you mention the modality and date. If there are multiple studies of the same date, you must mark the
time of examination. You will usually run into this with multiple chest radiographs on an ICU patient.

**Example**
Comparison: CT abdomen 8/15/04, abdominal radiographs 9/8/08 8:08 a.m. and 2:15 p.m.

**FINDINGS**
This may be the most difficult section for the new radiologist. Let us divide it based on the scenario.

**Scenario 1: Everything is normal**
Unfortunately the text, “Everything is normal. My attending even said so.” does not suffice. In this case, you may struggle with what to say in your reports. Remember to state the important negative findings.

**Example**
No fractures or dislocations are present. Joint spaces are well maintained. There is no soft tissue swelling.

**Scenario 2: You have a finding**
How to describe the finding: This is usually the same regardless of modality. Make sure you mention the following:
1. Size (give dimension – including craniocaudally if you can)
2. Location (specific segment of liver, part of the duodenum, lobe of brain, name of bone and location)
3. General shape, if applicable (ovoid, irregular)
4. Diffuse or focal (well circumscribed, irregular margins)
5. Comparison to the adjacent normal organ
   a. Hyperintense or hypointense in MRI
   b. Hyperdense (increased attenuation) or hypodense (decreased attenuation) in CT and plain film
   c. Hyperechoic, hypoechoic, anechoic in US
6. Heterogeneous or homogeneous texture (heterogeneously hyperintense)
7. Pattern of enhancement (or if it does not enhance)

**Example**
Findings: A 1.0 x 1.4 x 2.1 cm well circumscribed round hypodense homogeneous lesion in segment 4 of the liver is identified that does not enhance. No other hepatic lesions are present.

etc
**IMPRESSION**

Short and sweet. Go over this part with your attending. Make sure you know exactly what he or she wants to say.

You do not need to reiterate the descriptive terms or sizes exactly.

**Example**
Impression: Small left frontal meningioma.

If you feel that something associated with the finding is creating a clinical impact make sure you state it.

**Example**
Impression: Multiple bony metastatic deposits causing pathologic fracture of the humerus.

**Example**
Impression: Moderate left convexity subdural hemorrhage with 5 mm rightward transfalcine herniation.
If the diagnosis is not completely apparent, reiterate the finding and make your differential diagnosis in order of likelihood.

**Example**
Impression: Peribronchovascular ground glass lung opacities. Differential diagnosis includes vasculitis, septic embolus and bronchiolitis obliterans.

As a resident, you can track down whether the patient has had a fever or weight loss or exactly where the pain is and radiates. You may then be able to narrow your differential diagnosis. Now is the time to make that phone call to associate those clinical symptoms with the images.

**A FEW WORDS ABOUT DICATION DEVICES**
Most hospital based residency programs use voice recognition systems like “Dictaphone”, “Powerscribe” or “Talk” rather than a transcriptionist’s service. You may have either or both in your residency system, and your program should provide you with the technical basics of how to use the system. You will learn about the more advanced features, such as
templates for voice recognition systems and workflow statuses for transcriptionist’s services as you become more familiar with the systems. They are not important when you first begin your residency. The support staff will correct any technical mistakes you make (e.g., wrongfully associating examinations, misdirecting the report after dictation).

The largest difference between dictation systems, as you may already know, is editing. With voice recognition systems you will have to edit your reports at the time of dictation and take care of the ridiculous sentences the dictation system will create for you. With the transcriptionist system, the transcriptionist takes care of that for you, but you will have to recheck the report afterwards for medical or technical mis-transcriptions.

**DICTATION TEMPLATES**

Many residents use a template as a guide to remember which structures to look at or to make sure that certain negatives are included.
These may be quite detailed and not your entire template has to make it into the final report. For example, a template for a non-contrast CT of the brain may include statements about the normalcy of the central skull base and temporal horns of the lateral ventricles and may serve as a reminder for you to look at these structures.

Eventually you will decide what to leave in and what to take out of your final report. Soon you will not even need a template (which can reduce errors such as contradicting sentences) or your template will become minimal.

A word to the wise, it is quite easy to copy and paste a normal template and then add in a sentence about the abnormal finding. But beware: these templates often include a statement saying that all is well with your abnormal body part. You will definitely get deduction points from your attending when you mention spondylololithesis of L3-L4, but
you forget to erase the template statement that says the lumbar spine alignment is preserved.

Below, you will find some sample dictations for plain radiographs and CT examinations. Also, two Web sites are included that offer great sample dictations for most studies you will encounter as a resident.

**Cervical Spine Radiograph**

**Indication:** [ ]

**Technique:** [ ] views of the cervical spine

**Comparison:** [ ]

**Findings:** The cervical spine is visualized from C1-T1. No prevertebral soft tissue swelling is seen. Alignment is maintained without spondylolisthesis. No acute fracture is identified. The vertebral body and disc space heights are preserved. The odontoid process is intact.

**Impression:** Normal cervical spine

**Knee Radiograph**

**Indication:** [ ]
**Technique:** [ ] views of the [ ] knee

**Comparison:** [ ]

**Findings:** No fracture or dislocation is seen. No joint effusion is identified. No significant soft tissue swelling is seen.

**Impression:** Normal [ ] knee.

**Ankle Radiograph**

**Indication:** [ ]

**Technique:** [ ] views of the [ ] ankle (or: PA, lateral and oblique views of the [ ] ankle)

**Comparison:** [ ]

**Findings:** No fracture or dislocation is present. The ankle mortise is normal on the nonstressed views. No significant soft tissue swelling is identified.

**Impression:** Normal [ ] ankle.

*Most of the above radiograph sample dictations can be slightly adjusted to fit most bone radiographs*

**Chest 2 view Radiograph**

**Indication:** [ ]

**Technique:** PA and lateral views of the chest*

**Comparison:** [ ]
**Findings:** The lungs are clear without focal infiltrate, pneumothorax or pleural effusion. The cardiomediatinal silhouette is within normal limits. No osseous abnormalities are seen.

**Impression:** Normal Chest x-ray.

*A similar dictation can be made for a portable chest radiograph by changing the examination and technique.

**CTA Chest-Pulmonary Embolism with Intravenous Contrast**

**Indication:** [ ]

**Technique:** Helically acquired axial CT images were obtained at 3 mm slice thickness after the intravenous administration of[]. Coronal and sagital reformations were also obtained.

**Comparison:** [ ]

**Findings:** There is no pulmonary embolus or pneumothorax. The lung parenchyma is normal. The trachea and mainstem bronchi are patent. There is no thoracic lymphadenopathy. No pleural or pericardial effusion is identified. The heart is normal in size. Limited evaluation of the upper abdomen
demonstrates []. No osseous abnormalities are present.

**Impression:**
1. No pulmonary embolus.
2. Clear lungs.

**CT Abdomen and Pelvis with Intravenous Contrast**

**Indication:** []

**Technique:** Helically acquired [] mm axial CT images were obtained from the lung bases through the lesser trochanters after the intravenous administration of [].

**Findings:** The lung bases are clear. The liver, spleen, pancreas, adrenal glands and kidneys demonstrate a normal contrasted appearance. The kidneys enhance homogeneously and symmetrically. The portal veins, hepatic arteries and biliary system are normal. No free fluid or free air is present. The bowel and mesentery are normal. No adenopathy is present. The urinary bladder and (uterus/ovaries or prostate) are normal. No osseous abnormalities are identified.

**Impression:** Normal CT of the abdomen and
CT Head without Intravenous Contrast

**Indication:** [ ]

**Technique:** Contiguous CT axial images through the brain were obtained at [] mm slice thickness without the intravenous administration of contrast.

**Comparison:** [ ]

**Findings:** There is no hemorrhage, infarct, mass lesion or extra-axial fluid collection. The ventricles are normal in size and symmetric. Normal grey-white matter differentiation is present. The osseous structures are intact. The paranasal sinues are well aerated. The orbits are normal.

**Impression:** Normal head CT

There are many other studies besides those covered here that you will dictate as a resident. Below are links to two Web sites that provide sample dictations:

http://www.cornellrads.net/main/index.php (under the left navigation tab “Sample Dictations”)

The ACR does not take responsibility for the content of these outside sites or adequacy of the templates. At some point you should make your own template.

**SECTION B: THE THINGS YOU SHOULD KNOW: YEAR 2 AND BEYOND**

Make sure you read the section titled **Section A: The Things You **MUST** Know** before proceeding, even if you are already deep into your residency. On the other hand, this section may be information overload for someone who has not started or is just starting radiology residency. Again, the topics are based on the sections of the report.

1. Examination
2. Technique
3. History/Indication
4. Comparison
5. Findings
6. Impression

**EXAMINATION**
There are at least 5 things to include under your examination line (See Section A). To understand why these must be included, remember that we are not in an isolated world. A radiologic exam goes through the following process: examination/procedure ordered; examination/procedure performed; examination interpreted; report rendered; coding (CPT, ICD-9; see below for full description); Claim submission; and Appeal/resubmit claim as needed.

While we are directly involved with only the 3rd and 4th component (examination interpreted and report rendered), our dictation and reports indirectly affect the rest of the process. A poor or incomplete report may be incorrectly coded or coded to a study worth less in reimbursement. In addition, poor information conveyance will lead to clinicians trusting you less. After you become an attending, they will be less inclined to refer patients to you. It is better to learn now.
Stating the examination properly for billing purposes can be simple. To do so, you must understand that both the CPT code and ICD-9-CM 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. Basically it states at what price an exam, a patient visit, or a procedure is reimbursed compared to other medical services. Interpreting a PA chest radiograph is assigned 1.00 relative value units (RVU). In comparison, a Level 5 pediatric new patient visit is 2.77 RVU and a laparoscopy with lysis of adhesions is 21.42 RVU. Reimbursement by Medicare is based directly on the RVU.

**ICD-9**: ICD-9-CM stands for international classification of diseases, ninth revision with clinical modification. It is a code for symptoms or disease. For example, cough, abdominal pain, pulmonary hypertension, claudication and cerebral infarct all have ICD-9 codes.
Simply put, every report should have the examination type (CPT) and the disease or symptom of the patient (ICD-9). The former is easy to satisfy and is why the examination description is so important. The latter is more difficult to satisfy and is why you have probably heard that clinicians should not claim “rule out pulmonary embolism” as the clinical history. Rule out pulmonary embolism does not have an ICD-9 code. While a CPT can be coded, the ICD-9 code is not satisfied and the study is not reimbursed. For this reason, the clinical history is extremely important.

There is an important exception to this. The coders are allowed to place a primary ICD-9 code from your findings or impression. That is, if the study does show a pulmonary embolism, then the ICD-9 code for the disease “pulmonary embolism” is coded. The study is reimbursed as long as there is an appropriate EXAMINATION (see the criteria in the Section A) to code the CPT.
HISTORY

Let us revisit this portion of the report. President Clinton put into law through the 1997 Balanced Budget Act that the referring physician or practitioner must provide adequate clinical indications for testing. By law, you may actually refuse an examination if the clinician does not provide anything more than “rule out ankle fracture.” This may not be good practical advice, however. Our goal is to work with the clinician to answer the clinical question with the proper imaging examination.

You may call the clinician to ask for the relevant history. Even something like “ankle pain” is enough to suffice for billing purposes. But while you have the physician on the phone, you might want to ask him if he has had trauma, has cancer, is taking drugs causing osteopenia, or anything else that may be relevant to your exam.
You may look at the clinical notes and use that history for your examination. Use the Electronic Medical Record (EMR) if it is available to you. You are not allowed, however, to copy and paste the previous study’s history. If the patient had ankle radiographs last month for a fracture and the old report states “ankle pain” as the clinical history, unless explicitly stated, you cannot assume that this study is a follow up of the fracture or that the patient is still presenting with “ankle pain” even if it may seem obvious. You are going to either call the clinician or search the EMR.

Use the History section to satisfy the 2006 ICD-9 Editorial Advisory Committee criteria. This can be quite simple even if the patient does not have a discrete symptom.

**Example**

**History:** 45-year old male with abnormal LFTs

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**History:** 94-year old female with pain, status post motor vehicle accident

**Example History:** 78-year old male who is unconscious, status post fall

**COMPARISON**
Nothing to add in this section that is not already covered in the *Things You MUST Know* section.

**FINDINGS**
By now, you should be an expert in describing the location based on the first section of the chapter. Now you can add pertinent negatives. Pertinent negatives narrow the differential diagnosis and are based on either positive findings you have made or on the clinical suspicion.

For example, you find a heterogeneously enhancing liver. The differential diagnosis is extremely broad from fatty infiltration to hepatic fibrosis to portal thrombosis to tumor (which itself has a differential diagnosis) and others. Think back to your intern year--What
would you want to know? No ascites. Spleen size is normal. Normal contour to liver. No lymphadenopathy. Vascular invasion, or lack thereof. Anything else you can think of?

A clinician may ask for a study with a particular diagnosis in mind. For example, a CT angiogram of the chest is ordered for shortness of breath. Likely, the clinician is worried about a pulmonary embolus, so be sure to comment on this (No filling defect is present in the pulmonary arteries).

**Example**

**Examination:** CTA Chest with IV contrast with 3D reconstructions  
**History:** 47-year old male with SOB  
**Comparison:** None  
**Findings:** Left lower lobe consolidation process. Airways are patent. No pulmonary embolus.  
**Impression:** Left lower lobe pneumonia

**Example**

**Examination:** CT Abdomen with IV contrast with coronal reformations  
**History:** 57-year old female with abdominal distension  
**Comparison:** None
Findings: Small and large bowel distension without narrowing. No bowel obstruction. Abdominal parenchyma otherwise normal.
Impression: Ileus

IMPRESSION
After you have described your findings, make sure to include a few additional items:

WITH WHOM DID YOU DISCUSS THESE FINDINGS?
At the end of your impression, make sure you mark the date of any clinician contact, especially as it relates to the diagnosis. “Findings discussed with Dr. Cox on 9/4/08 15:34.” This is especially necessary when you are on call and the report is not finalized until hours later.

DID YOU SATISFY THE ICD-9 CODE REQUIREMENT?
The impression should be suitable for ICD-9 coding by findings. As stated earlier in the chapter, a positive finding such as a pulmonary embolism can make up for weak
clinical history and satisfy the ICD-9 criteria needed for billing. If there are no abnormal findings, the coders will have to use the clinical history.

**Example**
**History:** 51-year old female with left ankle pain
**Impression:** Normal left ankle
* The coders will code for ankle pain, a secondary billing code

**Example**
**History:** 51-year old female with left ankle pain
**Impression:** Left lateral malleolus fracture
* The coders will code for the fracture, a primary code and the pain, a secondary code

**Example**
**History:** 51-year old female. R/o ankle fracture
**Impression:** Normal left ankle
* The coders will not be able to code on any CPT or ICD-9 code. You have done your work for free.

**Example**
**History:** 51-year old female. R/o ankle fracture
**Impression:** Left lateral malleolus fracture
* The coders will code for the fracture, a primary code. You will get paid even without the history

**Example**
**Examination:** Right ankle radiograph  
**Finding:** No acute fracture. Ankle joint is anatomically aligned  
**Impression:** Normal Ankle  
*No information for indication (ICD-9). No positive findings—coders cannot code. Billers cannot bill. The report also does not have the number of views (CPT); this results in a 7% reimbursement difference.

**Example**
**Examination:** Needle localization for left breast calcifications  
**History:** Microcalcifications left breast  
**Technique:** Under usual aseptic conditions, medial left breast calcifications were localized using a needle/barb device. No immediate complications.  
**Impression:** Successful needle localization left breast calcifications  
*ICD-9 code provided (microcalcifications). However, coders cannot add a CPT code for ultrasound or mammographic guidance.

**Example**
**Examination:** CT Myelogram of the Lumbar spine  
**History:** Back and left leg pain
**Technique:** 3 mm sections obtained through the lowest 3 lumbar disks.

**Findings:** In comparison with earlier myelogram, L3-4 and L4-5 appear normal. There is a left paracentral disc protrusion at L5-S1 displacing the left S1 root.

**Impression:** Left L5-S1 disc protrusion with S1 root displacement
* Disc protrusion coded as primary ICD-9 code and symptoms (pain) as secondary ICD-9 code. No contrast (CPT) code added to dictation, so all of your effort to perform the lumbar puncture and intrathecal injection was not billed.

Imaging underwent a dramatic evolution in the past century. Radiology reporting has largely remained static while technology and the type, variety, age and styles of radiologists have changed. Prose reports have been criticized for inherent deficiencies including inconsistencies in content, structure, organization and nomenclature.

New initiatives and technology have changed the radiology reports from a free dictation to more of a standard text. For example the ACR created BI-RADS, a system for reporting
mammography, which has created standard breast imaging reports. On certain levels, RadLex, by the RSNA, is aiming to create standard nomenclature for findings.

**CONCLUSION**

Starting a radiology report as an inexperienced radiology resident can be daunting. The nuances of the proper report are complex. Follow the simple rules in the **Section A: The Things You MUST Know** when you get started as a first year radiologist resident. As you get more experienced, make sure you incorporate the ideas in **Section B: The Things You SHOULD Know**. Soon many of these points will become second nature. Stay flexible - new ideas and new fronts will come to radiology dictation and report creation.

**FURTHER READING FOR THE RESIDENT**

For further information about the economics of transcription and voice dictation:

Bruce Hillman, M.D. (Editor-in-Chief of JACR) editorial on the residents and the radiology report:

For more information on the radiology report including coding and billing:


For more information on current trends and the future of radiology reporting:


Special acknowledgment to William T. Thorwarth, Jr., M.D., FACR
7: INTRODUCTION TO FELLOWSHIPS

Fellowships are undoubtedly important. A significant majority of radiology residents pursue additional subspecialty training beyond residency. With the increasing emphasis on subspecialization, the ABR is also revising its requirements and suggested curriculum based on its belief that the future of radiology is in subspecialization. Fellowship training has afforded trainees many advantages such as higher compensation, increased competitiveness in the job market, and higher job satisfaction. Choosing a subspecialty area for fellowship training may not be a simple choice but there are many opportunities in radiology.

As you progress in your training, consider your clinical interests (Interested in sports medicine?), personality type (Are you a hands-on person? Do you love procedures? Want to run a clinic? Want to do research? Do you love children?), and academic interests (Interested
in developing the next innovative catheter? Want to develop the next technology to detect breast cancer?).

Remember, this is not an irreversible process. Radiology is a rapidly evolving field and fellowship training simply serves as a foundation for one to begin his/her career. You will likely continue to learn and gain skills as a radiologist as you progress in your career. Here are some of the most common fellowships available today to radiology residents considering further post-residency training. But also remember that many fellowships can be altered, rearranged or even created to meet your needs or future desires.

**ABDOMINAL IMAGING**

A number of abdominal imaging fellowships exist for those interested in focusing on the abdomen. Fellows can expect to gain additional expertise in cross sectional imaging with MRI, PET, and CT, as well as skills in CT colonography (CTC). Gaining confidence and
skill with abdominal image-guided procedures are also positives to abdominal imaging fellowships.

**BODY IMAGING**
For those who are interested in a chest and abdominal imaging, body imaging is a wide-ranging subspecialty within radiology. One can obtain training in multiple modalities that span MR, CT, PET/CT, ultrasound, radiography, and procedures (biopsy, drainages, nephrostomies, and feeding tube placement, to name a few). These fellowships tend to vary by institution with some being more procedure based and others having more cross sectional imaging. Body Imaging fellowships overlap with Abdominal Imaging fellowships.

**CARDIAC IMAGING**
The increasing role and use of cardiac CT and MRI has spawned a number of training fellowship programs. Fellows can expect to gain expertise in CT and MRI. Fellowships
offer the opportunity to become certified by the American College of Radiology as well as the American College of Cardiology in Cardiac CT. Additional time spent in 3-D processing, echocardiography, cardiac catheterization labs (observing opportunities), and pediatric cardiac MRI may offer additional opportunities for exposure.

**CHEST IMAGING**

If one wishes to gain additional skill performing image-guided procedures in the chest such as percutaneous lung biopsies, training in thoracic imaging may be beneficial. Additional training in chest MR and PET/CT may be part of this fellowship. Combinations with cardiac imaging are also common, with combination fellowships termed "cardiothoracic imaging" by some.

**MAMMOGRAPHY/ WOMEN’S IMAGING**

The demand for radiologists trained in breast imaging is increasing. Training typically includes development of expertise and
confidence in screening mammography, diagnostic mammography, breast MRI, needle localization, and image-guided biopsy. Many programs may also offer combined training in mammography and another complimentary specialty such as body imaging, where one can obtain training in cross sectional imaging of the abdomen/pelvis (including abdominal/pelvic MRI, sonohysterography, image-guided biopsy). The field of "women's imaging" is a growing area of specialty for radiologists. These custom/combined fellowships are becoming widely available and offer a well-rounded training opportunity.

**MUSCULOSKELETAL (MSK) IMAGING**

Musculoskeletal imaging fellowships have been one of the more popular fields among radiology residents. Fellows in MSK imaging often receive training in both diagnostic imaging techniques as well as interventional procedures. Diagnostic imaging techniques include a rich MRI experience as well as
CT/plain-film/ultrasound training. Training in image-guided biopsies, pain management procedures, and spine procedures vary by institution and are important aspects of training a prospective candidate should inquire about. The extent of cross-sectional imaging (CT/MRI) is also an important aspect to an MSK fellowship. Emphasis on sports medicine may also be of interest and should be considered by residents who are looking into this field.

**NEURORADIOLOGY**

Neuroradiology fellowships allow fellows to improve and increase their knowledge of CT and MRI as well as some basic neurointerventional diagnostic skills. Fellows learn to perform intracranial and cervical angiograms. Fellows may have an opportunity to learn MR Spectroscopy (MRS) and functional neurological imaging. This fellowship can be one or two years, depending on the fellows’ desire.
NUCLEAR MEDICINE
For those interested in functional imaging or oncologic imaging, nuclear medicine may be a fellowship to consider. As a radiology resident who pursues nuclear medicine fellowship, one can receive additional board certification in nuclear medicine. Fellows receive training in radionuclide studies, cardiac nuclear imaging and PET/CT.

PEDIATRIC RADIOLOGY
In the United States, there are a handful of dedicated children's hospitals. Although this thereby limits residents interested in pediatric radiology by geography, fellows are therefore offered highly focused and excellent opportunities to learn. Pediatric radiology fellowships are becoming more popular due to many reasons, including a good job market due to a shortage of pediatric radiologists and increasing use of advanced imaging techniques. Pediatric radiology fellowships focus on training in radiography, ultrasound, CT, and MRI predominantly. Due to the
increasing awareness of radiation exposure in the young population, emphasis on skills in radiography and ultrasound cannot be underestimated and are factors to consider when seeking a pediatric radiology fellowship. For those interested in obtaining training in interventional procedures in the pediatric population, this will also vary by institution. One also can pursue further subspecialty training within pediatric radiology such as pediatric musculoskeletal imaging or pediatric nuclear medicine.

VASCULAR AND INTERVENTIONAL RADIOLOGY (VIR)

For those with an interest in procedures and hands-on medicine, interventional radiology is a potential specialty to consider. VIR training affords trainees to gain skills in numerous procedures and running clinics. In addition, there may be opportunities to gain exposure to non-invasive vascular imaging (CTA, MRA, ultrasound). For VIR programs, prospective candidates should consider the volume of
cases, variety of procedures (vascular, non-vascular, oncologic, arterial-based procedures, venous-based procedures, interventional nephrology), and opportunities to run clinics. Practice patterns may vary depending on the institution. It is therefore also important to inquire about potential collaborative opportunities with other specialties such as vascular surgery, neuro/neurointerventional surgery, or general surgery.

**MODALITY BASED OR COMBINATION FELLOWSHIPS**

Nothing is written in stone. Often times, we simply cannot decide what to specialize in because there are so many interesting modalities, systems, and opportunities. This is certainly the case in the ever evolving and dynamic field of radiology. If the fellowship you desire is not advertised, you can speak with the fellowship directors about the possibility of creating a combination fellowship. Popular combinations by systems, for example, include Women's Health
(Combination of Abdominal or Body imaging with Mammography) or Cardiothoracic Imaging (Cardiac Imaging and Chest Imaging). Although the availability of modality based training programs (i.e. ultrasound or CT fellowships) currently are not widely available, there are still a number of institutions that offer MRI fellowships where for example, a trainee can gain experience in MRI as used in musculoskeletal radiology, neuroradiology, and body imaging. Several PET-CT and cross-sectional fellowships may also exist.

**NON-TRADITIONAL OR NON-CLINICAL TRAINING OPPORTUNITIES**

Interested in going beyond the reading room? There are definitely many opportunities in formal training that include but certainly not limited to medical and/or imaging informatics, management, quality and safety, basic/translational/clinical research, and medical education. Although many are not published, consider discussing opportunities with section heads/department chairs at
programs where you are interested in training. Many have even considered returning to school for more training such as obtaining a PhD, MPH, or MBA.
8: RESIDENT EDUCATIONAL RESOURCES

Numerous online and print resources exist to assist you in your education. The list below is not inclusive, but it is our best attempt to compile the most popular resources currently in use.

**General Resources**

*Fundamentals of Diagnostic Imaging, Brant & Helms* – This Radiology staple provides a comprehensive overview of the various disciplines and can serve as either an introduction for beginners or a review for upper levels. The newest edition is separated into several easy to carry volumes and has additional online materials.

*Radiology Review Manual, Dahner* – This encyclopedia of differentials is a useful reference particularly for board preparation. There are several detailed anatomy sections.

*Primer of Diagnostic Imaging, Weissleder et al.* – This text is in outline/summary form, and gives a comprehensive review of the different subspecialties of radiology. At the end of each chapter, a list of differential diagnoses is provided.

*The Requisites Series* – This is a series of
textbooks, each dedicated to a single organ system (i.e. Gastrointestinal Imaging, etc) that provides detailed information. The text has ‘Summary’ boxes at the end of sections and chapters. Can be used at all levels of training.

**Case Review Series** – As the name implies, this is a compilation of cases for each organ system. Useful for upper level residents and board preparation.

**Diagnostic Imaging Series** – This series is an extensive and helpful reference for use during daily practice. It is in a summary format with pictures, text and differential diagnoses. This series contains anatomy based editions as well as system-based editions.

**STATdx** – Created and published by Amyrsis (of Diagnostic Imaging), this resource is an online site that provides a wealth of detailed information specifically geared towards radiologists.

**Additional helpful Web sites:**

**Google** – The well known, general search engine offers excellent access to the widest variety of resources. Websites, electronic articles and texts, and images are immediately available. [www.google.com](http://www.google.com)

**Yottalook** – A medical imaging search engine. Access to thousands of images and radiology specific resources. [www.yottalook.com](http://www.yottalook.com)

**Radiographics** – Journal with many review
articles that are excellent for topic based study. For full website access a subscription is needed (your institution likely has one). [http://radiographics.rsnajnls.org/](http://radiographics.rsnajnls.org/)


**Learning Radiology** – Topic based modules (flash, PDF, PP), Case of the Week archives (lots of information, a little thin on images). [http://learningradiology.com/](http://learningradiology.com/)

**Anatomy**

*Anatomy in Diagnostic Imaging, Fleckenstien* – A nice introduction to multimodality imaging, with excellent radiographic images and detailed anatomic markings.

*Atlas of Human Anatomy, Netter* – Netter’s Atlas continues to provide excellent hand drawn anatomical teaching.

*The various pocket atlases (i.e. cranial MRI, body CT anatomy, anatomy head and neck)* – These portable atlases can come in handy depending upon current rotation.

*Atlas of Normal Roentgen Variants that may simulate disease, Keats and Anderson* – A good reference text to keep in the reading room, that can be referenced to check if what you are seeing is indeed a finding, or rather, a normal variant.
Additional anatomy websites:


**Emergency Radiology**

**Imaging in Trauma and Critical Care, Mirvis** – Comprehensive trauma text that is useful to read before starting call.

**Accident and Emergency Radiology, Raby et al.** – A less detailed trauma text, perhaps geared more towards ER physicians.

**Chest**

**Felson’s Principles of Chest Roentgenology** – A nice introduction or quick review of basic principles that can be easily completed in a weekend. The newest edition comes with a CD and additional cases.

**Thoracic Radiology: The Requisites, McCloud** – As described above, a series that encompasses all of chest radiology.

**Thoracic Imaging, Webb and Higgins** – A detailed text of thoracic radiology. An appropriate next step for upper level residents.

**Chest Radiology, James C. Reed** – A detailed text of thoracic radiology that is also considered an appropriate next step for upper level residents.
Synopsis of Diseases of the Chest, Fraser, et al – Extensive textbook, better used as an upper level resident.

Additional helpful websites:

Thoracic Radiology – Society of Thoracic Radiology page. Contains a written resident curriculum as well as corresponding web resources and images (although some of these are still incomplete at press time). [http://education.thoracicrad.org/online_edu.htm](http://education.thoracicrad.org/online_edu.htm)

Cardiac
Cardiac Imaging: The Requisites, Miller – A more advanced textbook that focuses more on angiography than CTA/MRA.

Gastrointestinal/Genitourinary/Abdominal Imaging
Fundamentals of Body CT, Webb et al. – An initial textbook for the lower level resident that orients one to cross sectional imaging.

Gastrointestinal Imaging: The Requisites, Halpert – As described above, a series that encompasses all of GI radiology.

Genitourinary Imaging: The Requisites, Zagoria – As described above, a series that encompasses all of GU radiology.
Textbook of Uroradiology, Dunnick et al. – A thorough textbook that can be used throughout residency training.

Body MRI, Siegelman – A thorough resource with MRI imaging of the chest, abdomen and pelvis.

Mayo Clinic Gastrointestinal Imaging Review, Johnson and Schmit – Extensive case-based review that covers the gamut of GI cases

CT and MRI of the Abdomen and Pelvis: A Teaching File, Ros et al.

Mammography

Breast Imaging: The Requisites, Ikeda – A thorough textbook that can be used throughout residency training.

Breast Imaging, Cardenosa – A thorough textbook that can be used throughout residency training.

Breast Imaging Companion, Cardenosa – Excellent text read after the above text, suitable for upper levels.

Breast Ultrasound, Stavros – Helpful for upper levels striving to improve their ultrasound skills.

Musculoskeletal

Musculoskeletal Imaging: The Requisites, Manaster, et al – A thorough textbook that
can be used throughout residency training.

**Arthritis in Black and White, Brower and Flemming** – A good review of the radiographic findings of arthritis.

**Musculoskeletal MRI, Kaplan et al** – An excellent introduction to MSK MRI.

**Orthopedic Imaging, Greenspan** – An excellent textbook that includes anatomy, trauma, tumor, arthritis, etc. Excellent for the younger resident and a great resource throughout training.

**Bone and Joint Imaging, Resnick** – Known as the “mini-Resnick”; thorough textbook, good as a reference

**Musculoskeletal Imaging: A teaching File, Chew and Roberts** – An extensive case based review divided by joint.

**Neuroradiology/Head and Neck**

**Neuroradiology: The Requisites, Grossman and Yousem** – This comprehensive text can be used throughout residency.

**Diagnostic Neuroradiology: a text/atlas, Osborn** – There is another comprehensive textbook.

**Nuclear Medicine**

**Nuclear Medicine: The Requisites, Ziessman, et al** – A thorough comprehensive textbook for nuclear medicine
Essentials of Nuclear Medical Imaging, Mettler and Guiberteau – A thorough textbook that can be used throughout residency.

Nuclear Medicine Imaging: A Teaching File, Habibian, et al – A comprehensive case-based textbook

Pediatric Fundamentals of Pediatric Radiology, Donnelly – A thorough textbook that gives a great overview. Great to use as a first year resident as well as a review for the more senior residents.

Pediatric Radiology: The Requisites, Blickman – A thorough, comprehensive textbook for pediatric radiology that can be used throughout residency.

PediatricRadiology.com – A pediatric radiology digital library that contains links to hundreds of websites with images and pathology correlation as well as textbooks, journals, etc. http://www.pediatricradiology.com

Ultrasound
Ultrasound: The Requisites, Middleton – This text provides an excellent, detailed introduction to ultrasound that can be used throughout residency.

Diagnostic Ultrasound, Rumack et al. – A
more thorough 2-volume textbook.

**Vascular and Interventional**

*Vascular and Interventional Radiology; The Requisites, Kaufman and Lee* – An excellent textbook for residents

**Handbook of Interventional Radiology Procedures, Kandarpa and Aruny**

**Physics**

*Review of Radiologic Physics, Huda and Slone* – An extremely dense text with a wealth of high yield material. However, most feel this alone is insufficient to pass the physics test.

*The Essential Physics of Medical Imaging, Bushberg et al.* – This hefty text provides a much more detailed discussion of Radiological physics. Many use as a reference, to further understand concepts.

*Radiology Review: Radiologic Physics, Nickoloff and Ahmad* – A middle ground between the previous two, this workbook-like text can be helpful in making Radiological Physics a bit more manageable.

**Essential of Nuclear Medicine Physics, Powsner** – A more simplistic review of Nuclear Medicine physics.

**MRI**

*MRI in Practice, Westbrook et al.* – An excellent discussion of MRI physics.
E-MRI – A complete, however somewhat basic site for understanding and utilizing MRI. Basic physics, advanced techniques, answers to common problems. Few pictures, mostly words.  [http://www.e-mri.org/](http://www.e-mri.org/)

**Fluoroscopy**  
**Fundamentals of Fluoroscopy, Houston** – A thorough text that assists fluoroscopy residents with both techniques and findings.