CT Basics: Computed Tomography Fundamentals
Module 5

1. **Title Slide**
   Welcome to CT Basics Module 5 – Patient Safety in Computed Tomography. This module was written by Lee A. Bradley, M.S.R.I.S., R.T.(R)(CT)

2. **License Agreement**

3. **Objectives**
   After completing this module, you will be able to:
   - Describe and use methods to measure patient dose.
   - Discuss the role of the computed tomography technologist in reducing radiation dose, including technical factor selection, positioning and shielding.
   - Explain the basics of occupational exposure in computed tomography.
   - Discuss special considerations for pediatric patients.
   - Describe ethical considerations, including the overuse of CT, appropriate imaging of pediatric patients and how protocols can affect scanning.
   - Use the basics of patient care to ensure patient safety, including protocols, venipuncture, contrast administration and informed consent.
   - Explain preprocedure and postprocedure instructions.
   - Demonstrate emergency procedures.

4. **Patient Safety**
   Although often forgotten in the day-to-day demands of the computed tomography department, the primary goal of the CT technologist is to obtain the best possible images while keeping the patient safe. By safety, we mean protected from unnecessary radiation, disease and sometimes even from themselves. It can be a tricky balance. After completing this module, you should have a good understanding of the best and easiest ways to ensure your patient’s safety.

5. **Measuring Patient Dose**
   The first task in protecting patients from unnecessary radiation exposure is to understand how to measure patient dose. The basic radiologic units of measurement for radiography apply to computed tomography. The roentgen is used to measure the amount of radiation that a person is exposed to—not necessarily how much radiation is absorbed, but the amount of radiation present in the surrounding air.

   The unit that measures the amount of radiation absorbed by an individual is the rad or the rem. The basic difference between rad and rem is that the rad is a measurement of how much radiation is absorbed, whereas the rem describes the type of radiation a person is exposed to and is used for personnel dose monitoring. The curie is used to measure radionuclide activity, not patient dose, so we won’t discuss it further.

   The international community has standardized the measurement of radiation exposure, absorption and equivalent; these measurements are known as the International System of Units, or SI units. Most significantly the rad has been replaced by the gray (Gy) and the rem has been replaced by the sievert (Sv). Converting a rad or rem to a gray or a sievert simply involves moving the decimal point.
For example, 1 Gy equals 100 rad and 1 Sv equals 100 rem. Several equations are used to measure patient dose in CT, but you won’t need to calculate dose. Scanners have an automatic feature that can perform those computations for you. Actual patient dose is approximate because of many factors that are unique to each patient and scan. If you need to know the exact dose to a patient, ask your physicist for help.

6. **CT Dose Indices**

Here’s a list of dose indices for computed tomography. The CT dose index, or CTDI, was the original equation used to measure patient dose. The U.S. Food and Drug Administration mandated its use in the 1970s; however, it’s only completely accurate for a single-slice scanner. A variation of the equation using the center and outside edge of a phantom can be used to calculate a weighted average dose (CTDIw).

Another version of the equation computes patient dose from a spiral scan (CTDIvol). Some sources contend that CTDIvol can undervalue the dose during a body scan by 30%. Therefore, CTDI should not be used as an exact measurement.

The multiple scan average dose, or MSAD, is the average dose per slice during a CT scan; it can be calculated using an ion chamber or thermoluminescent dosimeter. This measurement, which depends on pitch, is only accurate if there are multiple scans of the same body part. When the pitch is set to 1, the MSAD equals the CTDI. A pitch setting less than 1 results in an increase in MSAD because the slices then overlap. That being said, MSAD is rarely used.

The dose length product, or DLP, most closely approximates the actual radiation dose to a specific patient for a specific exam because it takes into account the amount of radiation exposure per section as well as how many sections are imaged. The DLP varies from case to case depending on the patient’s body habitus and height, but it’s a more accurate measurement than other formulas. The DLP is calculated using the equation DLP = CTDIvol x scan length.

Remember that all these measurements are based on calibrations performed for an individual scanner. The information for a given scanner taken from thermoluminescent dosimeters, ion chambers or phantoms should never be used for equipment other than that scanner. Each scanner should have its own quality control log book. Your physicist is the only person who should try to accurately approximate a true patient dose.

7. **Reducing Radiation Dose**

The as low as reasonably achievable principle, or ALARA, still applies in computed tomography. You can follow ALARA in a variety of ways:

**Patient education.** Just as in diagnostic radiology, patient education is key to reducing patient exposure in computed tomography. If you make patients aware of the importance of staying still and of following breathing instructions, you will have fewer repeated exams due to motion artifact. You must be willing to ask patients personal questions — simply inquiring if there is any metal on his or her pants isn’t enough. You must ask about any object that can affect the scan, such as body piercings, hearing aids and removable dentures. You do your patient a disservice if you have to repeat a scan because you forgot to adequately screen for certain items.

**Physician education.** Although you might not believe you have much control over the types of examinations ordered or the reason for the exam, you should understand your facility’s protocols and bring them to the attention of the ordering physician. Often the physician might ask you what the appropriate test is for a specific patient. Your radiologist is the best source of information for these types of questions.

**Positioning.** You should always take the time to properly position your patient. If your patient is not centered to the x, y and z axes, there’s increased dose to the patient while the tube compensates.
Misalignment of the patient also can cause excess noise. For example, positioning plays a large part in reducing dose during a CT scan of the head. If the patient’s chin is tucked toward the chest, it reduces any gantry tilt needed; therefore, you have a better chance of missing the eyes because gantries have a limited degree of tilt.

Shielding. There are two schools of thought regarding shielding in CT. One position dictates that shielding is always necessary for overall safety and patient peace of mind. Another theory holds that a misaligned shield could allow the x-ray photons to scatter underneath the shield, causing potential harm without providing any usable information. Shielding practices vary by institution, and you should discuss your institution’s policy with the medical physicist. If you decide to shield, remember to do so a full 360 degrees around the patient, because radiation comes from all directions in CT.

Technical factors. Remember those math calculations you had to perform in radiography to adjust the kilovolt peak (kVp) and milliampere seconds (mAs) for changes in the source-to-image distance, grid ratio and other technical factors? The good news is that the CT scanner does the calculations for you. The bad news is that you can’t always trust a computer to reduce patient dose. Each series in a full scan needs to be tailored specifically to the patient on the table. It can be a daunting task to take so many factors into consideration, but let’s look at the best ways to use each one. Each series in a full scan needs to be tailored specifically to the patient on the table. It can be a daunting task to take so many factors into consideration, but let’s take a look at the best ways to use each one.

8. kVp and mAs
   Just as in radiography, kVp controls the ability of the beam to penetrate tissue, so is used to adjust the contrast in an image. Increasing kVp for an obese patient or bony joint results in a decrease in noise on the images. Generally, the range for CT is 100 to 140 kVp, with stations increasing in 20-kV steps. When using mA modulation, increasing the kVp station also may increase the mA station, something to consider as you change scan parameters.

   The technical factor milliampere seconds, or mAs, controls the number of x-ray photons produced by the tube. An increase in mAs results in less noise in the scan but an increase in patient dose. It’s a delicate balance between using enough mAs to create a good image and not overirradiating the patient.

9. mA Modulation
   CT scanners use a type of automatic exposure control known as milliampere, or mA, modulation, although the exact name used depends on the manufacturer. For example, GE scanners use the term “auto mA;” Siemens scanners use the term “care dose.” mA modulation can work in several ways, depending on the specifications of the CT scanner.

   For instance on GE equipment, it can be adjusted based on the AP and lateral scouts, or for Toshiba scanners based on a single image. As the images on this page demonstrate, the CT technologist changes the mA based on body habitus, body part composition or the thickness of the body part. For example, the mA used in image A is lower than image B because patient A has a smaller body habitus than patient B.

   In the same way, image C shows that a lower mA is used to produce an image of the lungs than of the abdomen because x-rays can penetrate the lungs more easily. Image D shows that a higher mA is used to penetrate the thicker lateral projection of a patient than used for the thinner AP projection.

   The CT scanner’s computer automatically adjusts to the pre-set parameters without your input. Just remember that these automatic parameters don’t always result in the lowest dose to your patient.

10. Pitch
The easiest way to understand pitch is to imagine your patient on the CT table surrounded by a spiral. When the pitch equals 1, each spiral touches the next spiral. If the table moves 10 mm for every slice and the scan is acquired at a 10-mm slice thickness, then the pitch equals 1.

Increasing the pitch to 2 means that the table moves 20 mm for every 10-mm slice. The spiral now is stretched out to twice its original size, which cuts scan time in half but also means some data is missed. This sounds unreasonable—are you scanning the patient to get the best diagnostic study possible? True, but increasing pitch on localized scanning or for studies in which 1:1 slices aren’t required can avoid unnecessary radiation to the patient.

The reverse is true when you want the slices to overlap to get the most information possible. This involves adjusting the pitch to less than 1. For example, CT angiography is extremely useful to diagnose emboli, aneurysms and other abnormalities and is usually performed with a pitch of less than 1.

The computer receives enormous amounts of information that can be used during postprocessing to demonstrate every possible piece of tissue. Dose rates for these studies are obviously much higher, but generally the benefits outweigh the risks in these circumstances. Use the slider bar to adjust the pitch on this animation.

**11. Collimation and Gating**

Collimation in CT is not the same as in radiography, where the radiographer adjusts the size of the primary beam. In CT, the scan field of view, or SFOV, is set for each protocol. When planning the scan using a scout image, the CT technologist generally adjusts the display field of view, or DFOV, while the scan size stays the same. The patient is not spared any radiation by adjusting the DFOV.

So, you should consider using a larger display field of view to include all the required anatomy when you reconstruct images. Remember that you must have scanned the anatomy and acquired sufficient data to reconstruct the images you need. Therefore, adjust the scan field of view to minimize radiation exposure to the patient—just don’t cut out any anatomy at this point, because you can’t get the data back.

Gating is a technique generally used for coronary or pulmonary angiography studies. With gating, you synchronize the scan with a specific cardiac phase to get the most from the study without having to reinject the patient with contrast.

An electrocardiograph or a small contrast bolus is used to identify when cardiac function is optimal or certain arteries are brightest. This is often referred to as bolus tracking. One study suggests this practice can reduce patient dose by up to 70% without any drop in diagnostic quality.

**12. Detector Configuration**

CT scanners usually are described in terms of the number of slices, for example, “16 slice” or “64 slice.” What the number actually refers to is the largest detector configuration of the scanner. Most current scanners are third generation or higher; they are able to scan large volumes of tissue in a relatively short time.

This capability is the result of a curved detector array that can receive information from a fan beam while the array or beam or both elements move about the patient. Let’s look at a 16-slice scanner as an example; this scanner uses an array of 4 contiguous detectors. Each detector scans one-fourth of its width 4 times. So 4 detectors, each of which scans 4 widths, equals 16 slices. A configuration of more detectors equates to a higher patient dose.

The real benefit to CT technology is versatility. A truly diagnostic coronary angiography study requires at least a 64-slice scanner, or 16 detector rows each scanning 4 widths. However, that same scanner can be reconfigured to be a 16-slice scanner for a kidney stone study. In this case, 16 detectors combine all information into 1 width each.
13. **Occupational Exposure**

The National Council on Radiation Protection and Measurements, or NCRP, issues recommendations regarding dose limits for the general population and radiation workers. The recommended limit for adults who are exposed infrequently is no more than 5 millisievert (mSv) per year for a whole-body dose.

Adults who receive frequent exposure such as a hospital employee who works near radiation but is not a technologist and children younger than 18 should receive an annual dose of no more than 1 mSv. Occupational exposure for radiation workers should be no more than 50 mSv per year. In general, four types of monitors are used to measure occupational radiation exposure:

1. A film badge is an inexpensive, fairly accurate monitor designed for short-term use only. A film badge can be damaged easily.
2. A thermoluminescent dosimeter, or TLD, is more expensive but is also more accurate than a film badge and can be worn long term.
3. An optically stimulated luminescent dosimeter, or OSL, is even more sensitive than a TLD and also can be worn long term.
4. A pocket dosimeter provides an immediate readout but no permanent record. Pocket dosimeters are not routinely used in diagnostic imaging.

In most CT exams, the only person exposed to the primary beam is the patient inside the gantry. This means that all surrounding walls, including the control booth, are considered secondary protective barriers and only need to be designed to limit scattered radiation. According to NCRP recommendations, secondary barriers can contain 0.1 to 0.4 mm thickness of lead or the equivalent; the thickness depends on the wall’s proximity to the CT scanner.

When performing special procedures such as biopsies under CT-guided fluoroscopy, both the physician and CT technologist should take the same precautions as during regular fluoroscopy — full-body shield, thyroid shield, and protective gloves and glasses, when appropriate. Remember that scattered radiation from the patient is the technologist’s main source of radiation exposure, and mAs to the patient can be very high during CT fluoroscopy.

14. **Practice Question**

15. **Practice Question**

16. **The CT Order**

Your first step in patient care should be to verify the CT order. Physicians have a reputation for illegible handwriting, but even if you can read the prescription, you have to be sure of what the ordering physician wants. For example, assume that your scanner has built-in protocols based on the examination indications, and you receive an order for a CT chest scan for chest pain and shortness of breath.

For this patient, are you looking for evidence of a heart attack, pulmonary embolism or pneumonia? Asbestos exposure, lung cancer or interstitial lung disease? If your answer is “I have no idea,” then it’s time to verify the request. Every one of these indications can be a different type of CT protocol. To avoid a repeat exam, make sure you get the ordering practitioner what he or she wants the first time.

17. **Contrast**

One of the biggest challenges facing technologists who are new to CT is the use of contrast. When and why should oral contrast be administered? What type of IV contrast should be used for which
study, how much and how fast? In which cases would no contrast be used? Here are some very general guidelines on the use of contrast:

- **IV or oral contrast** is not used to investigate kidney or gallbladder stones, that is, for so-called “stone studies.”
- Positive oral contrast, barium or iodine-based oral contrast is used to highlight the digestive tract. It can show changes to the bowel lumen, define the boundaries of a potential mass and help the radiologist differentiate between the digestive tract and surrounding organs such as the liver, pancreas and spleen. When imaging the entire abdomen/pelvis area, this type of contrast generally is administered 1 to 4 hours before the exam.
- In emergency situations, a few cups of contrast are better than none at all, because it helps to outline the major organs in the upper abdomen. Oral contrast can be used during the CT scan to evaluate the esophagus, much like a barium swallow in diagnostic radiography.
- Negative oral contrast such as water, milk or a specially weighted barium sulfate can better define the bowel wall without superimposition. Because these contrast media distend the digestive tract without highlighting it, they don't cause streaking artifacts on the images or conceal pathology such as stones. Also, they won't obscure vasculature during IV injection. However, dosing can be more difficult: water tends to pass through the patient quickly, milk is not always well tolerated and a large amount of the barium sulfate must be administered directly before the examination.
- Barium or iodine-based rectal contrast is administered to highlight the large bowel when oral contrast is not appropriate, or when oral contract did not adequately fill the colon. With this type of contrast, patients are prepped as they are for barium enemas at your facility. Barium enema bags and rectal tips can be used in the same manner for CT as for a regular barium enema.
- IV contrast demonstrates the circulatory system, various organ tissues, infectious processes such as Crohn’s disease, abscesses and cellulitis, and abnormal growths. The timing and volume of a contrast bolus injection varies significantly depending on the equipment used, facility protocols and availability of an injection site.

18. **Contrast Contraindications**

True and insurmountable contraindications to the contrast used for CT are rare. Most problems can be overcome with preparation and planning. Allergies to iodine or other medications can be handled using a steroid preparation approved by your facility. Nausea and vomiting that prevent the administration of oral contrast can be controlled by medications or, in extreme cases, by the use of a nasogastric tube.

Nephrotoxicity is a contraindication and possible side effect that is becoming more common with the increasing use of CT exams. Methods to avoid nephrotoxicity include extra fluid intake or premedication using acetylcysteine, although it's unclear whether premedication is helpful. Freestanding facilities and hospital radiology departments have institution-specific policies and protocols for injection.

These guidelines can vary widely, based on several factors including the type and amount of contrast and the patient’s age, gender and laboratory values. Other contraindications include asthma, multiple myeloma, pheochromocytoma, certain thyroid diseases, sickle cell anemia and myasthenia gravis.

Contrast reactions in patients with these diseases vary, but in general an injection of contrast aggravates the condition. Yet the benefits of CT often outweigh the risk to the patient, so if there’s a question about contrast administration, you should consult the radiologist.
19. **Power Injectors**

Generally, when a patient requires IV contrast, the CT technologist uses a power injector. A power injector automatically draws up the necessary amount of contrast into a syringe. The technologist connects the syringe to the tubing, forces out all the air and connects the device to the patient’s IV site, which has been flushed with saline.

There are two kinds of power injectors: singles and doubles. Most studies only require a single syringe filled with contrast. A few examinations, however, depending on department protocol, use a syringe filled with contrast and a second syringe filled with saline. In these cases, the saline is administered before the contrast to assess the line for power injection and following contrast administration to help push the contrast and to automatically flush the line.

20. **Venipuncture**

Part of a CT technologist’s job is to assess IV sites, but you also might be called on to start the IV, a process known as venipuncture. Accessing a vein for injection might be unfamiliar to some technologists, but it’s a very useful skill to know when no nurses are available or if you work at an outpatient facility.

The first step is to determine the catheter size, which is based on the type of CT exam you’re performing. Note that the smaller the number of the catheter, the larger the gauge; so an 18-gauge catheter is larger than a 22-gauge device. For an angiogram, you need to place a large-gauge catheter in a large, proximal vein to adequately opacify the vessels.

If, on the other hand, you are assessing an extremity for cellulitis, a smaller catheter may be used because the scan already has a fairly long delay. Use your best judgment when choosing a site to start the IV. A site that can accommodate the largest gauge possible, closest to the antecubital vein and on the unaffected side (if relevant) is usually the best choice regardless of the test performed.

21. **Venipuncture Procedure**

To safely begin an IV line, follow these steps:

1) Wash your hands, and put on gloves.
2) Select the site and the appropriate angiocatheter. Keep your adapter handy. Remember to prime the extension with saline.
3) Wrap the tourniquet approximately 2 inches proximal to the access site.
4) Cleanse the site using the method preferred by your facility, such as with an alcohol prep pad.
5) Remove the cap from the angiocatheter. Insert the needle as close to parallel with the skin as possible.
6) If you see a “flash” of blood within the catheter, you’ve gained access to the vein. Advance the catheter into the vein while withdrawing the needle into the safety device.
7) Release the tourniquet.
8) Secure the catheter before unhooking it from the needle. Place a 2 x 2-inch gauze pad under the catheter in case of blood leakage.
9) Screw the adapter onto the catheter. Advance a little saline into the vein, then withdraw a little. There should be a nice blood return. If there’s no return, pull back on the catheter slightly. If this action doesn’t provide a blood return, start again. Don’t dig around in the patient’s vein. It can be very painful and damage surrounding tissue.
10) When you’ve established a good return, further secure the catheter with whatever method is used by your facility.
11) Wash your hands.
22. **Extravasation**
   
   After starting the injection, the IV site should be monitored as long as possible before beginning the scan. No matter how good the IV line is, extravasation can occur at any time during an injection. Extravasation is when the contrast leaks into the surrounding tissue instead of flowing into the vein. Stop the injection immediately if this occurs, and call for help if necessary.

   There are competing theories about how to treat extravasation. A cold pack can be used to reduce swelling; however, a hot pack helps dissipate the contrast by reducing viscosity. Regardless of how it is treated, extravasation can be a very serious complication for the patient.

   Even if you take every available precaution, extravasation can cause ulcerations, compartment syndrome or tissue necrosis. Make sure to properly document all cases of extravasation, according to your facility’s safety guidelines.

23. **Central Access Devices**

   The patient may arrive for the CT examination with only a central access device such as a port-a-cath or a peripherally inserted central catheter, known as a PICC line. These devices are used to administer long-term antibiotic therapy, chemotherapy or total parenteral nutrition. Institutions have very strict guidelines regarding if and how these devices may be used for injection, because most of them are not approved for power injection of contrast media.

24. **PICC Lines**

   A PICC line is placed in one of the veins in the general area of the elbow. The catheter then is threaded upward into the chest to the superior vena cava. There are two types of PICC lines: regular PICC lines and those approved for power injection, or power PICCs. Regular PICC lines may be inserted at the patient’s bedside, but the patient is taken to the interventional radiology suite for a power PICC placement.

   In certain cases, the radiologist may allow use of a regular PICC line for iodinated contrast injection; however, you must change the injection rate and pressure. You first must determine whether your patient has a regular or power PICC before attempting to inject through the device.

   Injecting contrast at high speeds and pressures can damage not only the device, but also your patient. Always consult your radiologist and the PICC-line policies for your facility.

25. **Port-a-Cath**

   Port-a-caths are used to administer the same type of fluids as a PICC line, but are mostly prescribed for chemotherapy. These devices are implanted under the skin in the operating room while the patient is under anesthesia. No part of the port sticks out above the skin, although the port is clearly visible through the skin. Port-a-caths must be accessed with a special needle and generally should be treated with heparin before and after use.

   As with PICC lines, there are regular and power ports. A regular port-a-cath should never be used for power injection at any speed or any pressure. Patients with a power port usually have a wallet card identifying the device, or the port is marked with the letters CT that are clearly visible on a chest radiograph.

26. **Perm-a-cath**

   A perm-a-cath is similar to a PICC line, but the catheter is much shorter and accesses the major vein closer to the heart, in the area of the subclavian vein. These devices are used for dialysis and are never to be used for any contrast injection.

   Patients with a PICC line or a port-a-cath also may have a regular IV site; just because a patient has a central access device doesn’t mean that you can’t start an IV. If you can’t obtain peripheral IV
access, you should defer to your facility’s protocol regarding power injection through central access devices.

27. **Prescan Procedures**
   Patient preparation for CT can vary widely depending on the protocol, diagnosis and contrast used. Most institutions require patients receiving IV contrast be on a clear liquid diet or to take nothing by mouth (NPO). Bowel preparation can include barium or iodine-based oral solutions, and even rectal contrast, administered 1 to 4 hours before the exam.

   You should ask if the patient has undergone any other CT or radiography studies that required bowel prep within the past few days. The barium used for a regular fluoroscopy study is more dense than that used for a CT exam. It causes streaking on CT images and could possibly ruin the study altogether, particularly noncontrast studies such as a kidney stone protocol or spine exam.

   In that same vein, check each patient’s diagnostic testing orders to determine if the CT scan needs to be scheduled around other modalities. For example, patients often need to be NPO for an ultrasound or nuclear medicine study.

28. **Prescan Procedures**
   Make sure to remove any metal located within a few inches of the area of interest. Remember that just because the object isn’t included in the display field of view doesn’t mean that it won’t affect the final images. Reconstructed scans such as the spine are particularly vulnerable to beam hardening from artifacts within the scan field of view.

   The CT technologist is responsible for verifying the patient’s history, including all allergies and medications. Follow your institution’s guidelines regarding steroid preparations for iodine allergies and postscan procedures for patients on certain medications. You are the last line of defense for your patients, and their well-being is your responsibility.

29. **Metformin**
   The drug metformin is an example of why it’s important to verify the patient’s medications. Metformin comes in many formulations and is prescribed to control blood sugar in patients with type 2 diabetes. This page contains a brief list of metformin medications; however, you should consult the most up-to-date information available because new therapies that may include the drug are constantly being introduced into clinical practice.

   Metformin is not necessarily a contraindication to undergoing a CT scan with IV contrast, but patients should stop taking their medication for 48 hours after the injection. According to Bristol-Myers Squibb, one of the manufacturers of metformin, IV contrast can cause acute renal failure, which then can lead to a potentially toxic build-up of the drug in the patient’s kidneys.

   Blood tests are needed to assure normal kidney function before the patient can resume taking metformin. Follow your institution’s guidelines for postprocedure metformin use.

30. **Patient Consent**
   Patient consent is sometimes a confusing topic. Patients who are admitted to the hospital usually have given consent for treatment, including diagnostic testing. However, any invasive procedure such as a biopsy or an abscess drainage generally requires a separate consent form signed by the patient and radiologist performing the procedure.

   Keep in mind that any patient can refuse any test at any time; patients also can refuse to undergo part of a test. For example, a patient might drink the bowel prep for an examination but not allow the IV injection. In these cases, defer to the radiologist’s judgment regarding how to proceed.
There is no hard and fast rule in the United States regarding outpatient consent. Some institutions require a consent form signed after a discussion with a radiologist, while others may not. Ask your institution’s risk manager which health care personnel can obtain patient consent at your facility.

31. **IV Lines**

If an inpatient comes to the radiology department with an active IV line, you can’t automatically turn off that IV and use it as an access point. Many medications need to be administered at a continuous rate to be effective, including blood thinners such as heparin or cardiac medications such as diltiazem. If you’re unsure whether you can use an IV line, consult a pharmacist, radiologist or radiology nurse.

If you do use an existing IV line, make sure you flush the line with saline before and after injecting the IV contrast, and that you reconnect the medication using the same injection rate as when the patient arrived in the department. You must remove the IV line of outpatients who aren’t undergoing further testing before they leave the radiology department.

First, wash your hands then put on gloves. Have gauze and tape handy. Loosen any tape over the IV clave, cover the site with gauze and remove the catheter. Immediately apply pressure to the IV site with the gauze. Don’t simply tell the patient to bend his or her arm, as this can lead to a hematoma. If the patient is taking a blood thinner, keep applying pressure.

Check for any residual bleeding at the site after a minute. Cover the site with an adhesive bandage if bleeding has stopped. If there’s a little blood, make a pressure bandage with a small piece of gauze and medical tape. If the IV site is still bleeding openly, continue to apply pressure until the bleeding stops.

32. **Postscan Instructions**

Postprocedure instructions depend on the scan performed. Although the barium administered for CT exams is less dense than that used for radiography, you should still advise your patients to drink plenty of water for the next 24 hours to ensure easy passage of the preparation.

Protocols vary by institution, but especially when it comes to postinjection instructions for patients taking metformin or any of its derivatives. Noncontrast exams don’t require follow-up instructions. Make sure you are familiar with your institution’s protocols.

33. **Ethics in CT**

Medical professionals want to do what’s best for their patients, but we don’t always agree on what that is. If you ever have a question about why a test was ordered or how to go about getting the best scan possible, you must try to get the answers to your questions. You aren’t helping your patient by making assumptions or guessing the best course of action.

Overuse of medical testing is an important issue. An NCRP report released in March 2009 stated that approximately 67 million CT scans were performed in the United States in 2006. Out of a total U.S. population of 304 million that’s an average of about 1 out of every 4½ people having a CT scan that year.

Now, if that were really the case, there wouldn’t be cause to worry. Unfortunately, numbers can be misleading. For example, a retrospective study published in the April 2009 issue of the American Journal of Roentgenology reported that 1 patient had undergone 70 CT scans in 8 years.

Part of the CT technologist’s job is to provide the physician all the pertinent facts concerning the patient, including the number of scans the patient has had in the recent past. Be sure to inform the physician or radiologist if your patient has undergone several scans of the same body part for the same reason. There may be other more appropriate tests that provide the same information but deliver less radiation.

The American Society of Radiologic Technologists (ASRT) has developed practice standards that define what constitutes acceptable practice in computed tomography. The clinical performance
standard concerning assessment states that the CT practitioner “Reviews the patient’s medical record to verify the appropriateness of a specific exam or procedure.” If you believe that an examination is inappropriate, you are well within your scope of practice to query the ordering physician or radiologist about the exam.

34. Practice Question

35. Practice Question

36. Practice Question

37. Restraints
   The use of restraints is another major topic in the area of CT patient safety. Technologists often use safety straps on the CT table to assure proper positioning and to restrict movement. The use of straps may be justified for patients who can’t give informed consent and who aren’t able to remain still during a scan under other circumstances.

   For example, it’s preferable to immobilize a child using restraints rather than have a parent or technologist hold the child. Not only does a full-body device generally keep the child from moving, but it also limits the amount of nondiagnostic radiation exposure to family members or personnel.

   Trauma victims or patients with altered mental status are other good examples of when it’s appropriate to use restraints. Often patients don’t understand where they are and they try to get off the table. Restraints ensure patients don’t injure themselves, and at the same time restraints help to get a good scan.

   The use of adhesive tape is never recommended for patient restraint. Not only does it frequently come undone at inopportune moments, but it also can hurt the patient. For example, elderly patients tend to have thinner skin and are particularly vulnerable to skin tears. Tape is the absolute last resort, but if you do use it, don’t put the sticky side of the tape in direct contact with the patient’s skin. Flip the tape over so that the non-sticky side holds the patient in place or use a barrier such as a sheet between the tape and the patient.

38. Pediatrics
   One of the biggest challenges for a CT technologist is scanning a baby. Infants not only kick and scream, but their nervous parents may think that you’re harming the child. Remember that your primary responsibility is to the patient and that means getting the best scan possible with the least amount of radiation exposure. Although the use of restraints can be beneficial, restraints can be disturbing to a nonprofessional.

   Make sure you fully explain to the parents the benefits of using a restraining device. If parents insist on remaining with their child, allow only one in the room during the exam, because two adults can distract the child and ultimately cause motion. If someone has to hold the pediatric patient during a scan, make sure the individual removes all jewelry from his or her hands. There’s nothing worse than getting an otherwise good scan of a baby but having artifacts from the mother’s ring.

   It is also important to ensure that whoever immobilizes the baby in the room is properly shielded. The most important thing to remember when scanning pediatric patients is ALARA, or keeping the dose as low as reasonably achievable.

   Following ALARA means using pediatric protocols when appropriate and modifying technical factors if necessary. To promote responsible practices in pediatric imaging, thirteen organizations have launched the Image Gently campaign, an initiative to help lower radiation dose to pediatric patients.
39. **Image Gently**

“Image gently” is a phrase coined by the Alliance for Radiation Safety in Pediatric Imaging to remind medical imaging professionals that children need special consideration during imaging. Pediatric patients are at much higher risk than adults for radiation-induced illnesses such as cancers. In general, children have a longer life expectancy than the average adult; therefore, children have more time to accumulate a higher lifetime dose than adults.

So what can CT technologists do to protect their pediatric patients? CT scanners have built-in pediatric protocols, but you can always change scan parameters when appropriate. Adjust kVp, mAs, pitch and other technical factors as necessary to match your patient. The Image Gently website [www.imagegently.org](http://www.imagegently.org) has many resources to help build protocols for your equipment, plus charts to help you adjust scanning parameters on a per patient basis.

You should consult your medical physicist to help develop protocols for your facility. If you have questions about multiphase scanning, talk to your radiologist. For example, you might wonder if preinjection or delayed imaging is truly required.

You might question if it’s necessary to repeat the entire scan if the patient moves during the exam. Use all the resources at your disposal to ensure the best quality images with the lowest possible dose for all of your patients, but especially for your pediatric patients.

For more information, contact any member organization of the Alliance for Radiation Safety in Pediatric Imaging, including the American Society of Radiologic Technologists (ASRT), the American Registry of Radiologic Technologists (ARRT) and the American College of Radiology (ACR).

40. **Pregnant Patients**

Pregnant patients represent a unique set of problems for the CT technologist. Scanning a pregnant patient can be intimidating for the technologist and upsetting for the patient. If you have any questions regarding the test ordered, you should clarify the request with the ordering physician or radiologist. After making certain that the physician is aware of the patient’s pregnancy status, your job is to obtain the best possible images without harming the fetus.

This generally is not difficult to do with appropriate shielding. Wrap the patient in 360° of lead, starting just above the level of the pregnancy bulge, or about halfway between the xiphoid tip and the anterior-superior iliac spine. Carefully examine your scout images to determine if the shield is in the best spot before you proceed with the test.

Abdominal CT scans during pregnancy should only be performed under the most urgent pressing circumstances. A chest scan is the CT examination most often performed on pregnant patients. Pulmonary embolism is a very real concern for pregnant women and one of leading causes of death during pregnancy in industrialized countries.

Nuclear medicine ventilation-perfusion scans are a viable alternative, but CT angiography of the chest is the preferred diagnostic test for pulmonary embolism. The U.S. Food and Drug Administration categorizes drugs according to their safety during pregnancy. Radiopaque noniodinated contrast media are classified as pregnancy category B drugs, as are several common over-the-counter drugs such as acetaminophen and ibuprofen.

This classification means that several studies in pregnant animals showed no adverse effects to the fetus; however, no studies have been performed in pregnant women. If your patient has any questions about contrast or other medications, contact the ordering physician or radiologist. What if your patient doesn’t know whether she’s pregnant? If pregnancy is a possibility, ask the physician to order a pregnancy test.

This request applies to teenagers and older women alike because it’s possible for girls and women to become pregnant from puberty through menopause. The safest course of action is to never...
make an assumption about your patient’s pregnancy status. You should defer to your institution’s policy for patients who are breastfeeding.

Some hospitals recommend that the patient pumps and discards her breast milk for 24 hours after a procedure with contrast; other institutions may state that contrast is excreted unchanged through breast milk and therefore will be excreted unchanged through the baby’s digestive tract. There is no hard-and-fast rule; the important thing is to discuss this issue with the patient before injecting contrast.

41. **Emergency Situations - Equipment**

All scanners have abort buttons on the keyboard and on the gantry. Don’t be afraid to stop the procedure if you fear for the patient’s safety—it’s always worth it. Pushing the abort button stops any scanning in progress and may cause the table to float freely. There also might be safety parameters built into the table, such as an auto-stop if an object is in the way. The key to handling emergencies is preparation, and one of the best ways to prepare is to be familiar with your scanner’s emergency procedures.

42. **Emergency Situations - Patient**

Contrast injection can be hard on a patient’s body. Your patient may get a warm, flushed feeling; have pain at the injection site, especially peripheral sites like the hand; experience a metallic taste; or feel a flush in the pelvis. It’s important to warn your patient about these common contrast injection reactions. Vomiting is another potential injection side effect.

Warn your patient ahead of time that he or she can roll to the side when feeling ill. Keep an emesis basin handy during studies with injected contrast; if a basin is needed, you’ll need it quickly. Nausea from injection tends to pass rapidly, and often delayed images can be obtained without moving the patient out of position. Never leave a patient unattended after the contrast injection, even if he or she begins to feel better.

More serious reactions to radiopaque contrast media can occur for up to 1 hour after injection. These effects can include hives, dyspnea and shock. If your patient experiences any of these reactions or the patient’s condition worsens, call a radiology nurse or physician immediately.

43. **Emergency Situations - Patient**

Radiology departments are equipped with crash carts in the event of a patient emergency. You should know the crash cart’s location and be familiar with its contents in case your help is needed during an emergency situation. Most carts are equipped with a cardiac monitor/defibrillator, multifunction pads, a resuscitator bag and mask, intubation supplies and various medications.

Your role in an emergency is defined by state laws and your institution’s policies. According to the ASRT computed tomography scope of practice, duties of the CT technologist include “preparing, identifying, and/or administering contrast media and/or medications as prescribed by a licensed practitioner, where state statute and/or institutional policy permit.”

Even if you aren’t allowed to administer medications to the patient, you should be familiar with the contents of your crash cart in case you have to assist the physician or code team. You might find several of the following medications in your crash cart:

- **Lidocaine** is a local anesthetic used to numb small areas. It also can be used for ventricular arrhythmia.
- **Atropine sulfate** generally is used to increase heart rate.
- **Epinephrine**, or Adrenalin, opens airways and increases heart rate.
- **Dopamine** is a neurotransmitter similar to epinephrine.
- **Sterile water** is used to dilute other medications.
- Dextrose 50% is used to raise blood sugar.
- Aspirin is used to treat suspected heart attack.
- Nitroglycerin is a vasodilator used to treat angina.
- Naloxone reverses narcotic effects.
- Medications such as methylprednisolone, or SoluMedrol, reduce inflammation.
- Antihistamines, such as diphenhydramine, are used to treat allergic reactions.

44. **Basic Life Support**
Many CT technologists are trained in basic life support, including cardiopulmonary resuscitation, or CPR. If a patient suddenly stops breathing or the patient’s heart stops beating, call a code or dial 911 as appropriate. If you’re not sure you know what to do in a patient emergency, it’s time for a refresher course. Contact your local chapter of the American Red Cross to schedule a CPR class.

45. **Practice Question**

46. **Practice Question**

47. **Conclusion**
This concludes Module 5: Patient Safety in Computed Tomography. You should now be able to
- Describe and use methods to measure patient dose.
- Discuss the role of the computed tomography technologist in reducing radiation dose, including technical factor selection, positioning and shielding.
- Explain the basics of occupational exposure in computed tomography.
- Discuss special considerations for pediatric patients.
- Describe ethical considerations, including the overuse of CT, appropriate imaging of pediatric patients and how protocols can affect scanning.
- Use the basics of patient care to ensure patient safety, including protocols, venipuncture, contrast administration and informed consent.
- Explain preprocedure and postprocedure instructions.
- Demonstrate emergency procedures.

48. **Bibliography**


49. Bibliography (continued)


50. Bibliography (continued)


51. Development Team

52. Final Slide