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## RADIOLOGY: THE ADVANCED MODALITIES

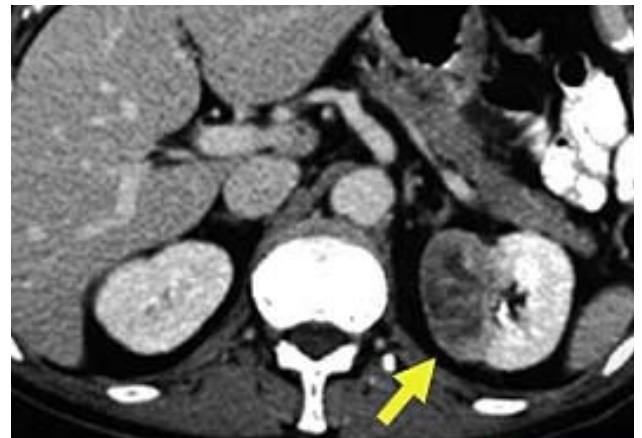
### Computed Tomography (CT), Part Two

#### CT Contrast Agents

#### CT CONTRAST

A contrast agent is a substance that, when inside the patient's body, highlights certain organs or structures and makes them easier to see. Contrast agents are used in almost every type of medical imaging, including fluoroscopy (to be covered in a later issue), ultrasound, CT, and MRI. It is extremely common to use contrast in CT. There are two main types:

- **Intravenous contrast.** This is a clear, iodine-based liquid that is usually injected intravenously into the patient with a machine that delivers it at a specific rate. The contrast agent appears white on CT scans, and localizes to blood vessels and all areas of the body that receive a blood supply. This allows a radiologist to assess for abnormalities in blood vessels, structural abnormalities of organs, and abnormal tissues (like tumors) that either receive too much or too little blood supply. When a physician orders a CT scan "with contrast" or "without contrast," they are referring to IV contrast only.



*This CT scan of the abdomen shows a tumor in the left kidney (arrow).*

- **Enteric contrast.** Enteric contrast can be delivered orally or rectally. It is usually a substance known as Gastrografin, a clear, bitter-tasting liquid that appears white on CT scans. When the patient drinks it, this fluid travels down the normal path of ingested food into the esophagus, stomach, and small intestine. By the time the patient is scanned it is usually in the small intestine, allowing us to see abnormalities in this area better. This also helps the radiologist distinguish small intestinal loops from other organs or masses in the abdomen, which can be difficult without contrast when the intestine is empty and collapsed.

When administered rectally, Gastrografin travels up through the colon. This allows the radiologist to see the distended colon to assess for inflammation (such as diverticulitis or appendicitis), abnormal position of the colon, or a mass – although CT is relatively insensitive for colon masses.

#### CT TERMS

#### Important Terminology

- **Gantry:** The donut-shaped unit that contains the x-ray machines and detectors.
- **Table:** The flat bed that transports the patient through the gantry.
- **Collimation:** Slice thickness (the depth of tissue that is included in each image) – on average about 5 millimeters.
- **Pitch:** How fast the table moves with every rotation of the gantry, relative to the collimation (that is, how many slices are acquired with every rotation of the gantry).
- **Hounsfield Units:** A quantitative measure of the density of tissue, as calculated by the computer based on the information received by the detector. The following are some approximate values for common substances:
  - Air = -1,000 HU    – Water = 0 HU    – Bone = 1,000 HU
  - Fat = -15 HU    – Muscle = +40 HU
- **Attenuation:** Another word for density, referring to how easily an x-ray beam travels through

a specific tissue.

- **Helical (spiral):** The gantry rotates 360 degrees around the patient as the table moves through it continuously, rather than taking one slice at a time.
- **Multidetector CT:** A scanner that has more than one detector (up to 64) and thus can obtain more than one image (or slice) at a time.
- **Multisource CT:** Multiple sources of x-rays are used in the gantry, allowing a greater area of the body to be imaged at the same time.
- **Reformatting:** Using the raw data obtained by the scanner to make a “reformatted” image in a different plane or using different window techniques.
- **Maximum intensity projection (MIP):** A type of reformatted image that displays all the highest-density points in all the slices, allowing for a two-dimensional view of three-dimensional anatomy, similar to a plain x-ray. This is useful for seeing blood vessels, which become very bright (high in density) after contrast infusion. For example, a MIP image could be created from a contrast CT of the head, in order to see all of the blood vessels of the brain.
- **Three-dimensional (3D) rendering:** There are two main ways to display CTs three-dimensionally:
  - **Surface render:** This is a 3D view created by using only the data points on the very surface of the brain.
  - **Volume render:** This is a more complex, time-intensive form of 3D rendering, which produces an image by using all of the data and makes areas with more depth darker and areas at the surface brighter.
- **Time-resolved:** CT images of the same area taken at multiple time points, to see their change over time. This is used in contrast-enhanced scans, usually angiography, to see changes in blood flow and contrast enhancement.

## CT USES

### Common Uses of CT

#### Brain

- A CT of the brain is a good initial test for a patient with an acute problem (such as headache, head trauma, or weakness). It is excellent at looking for blood, which usually looks bright white on CT.
- A CT of the brain is fast, and the brain is relatively resistant to radiation, so CT is widely used in these situations.
- A CT of the brain is almost always done without contrast, because contrast (which appears white) can obscure blood. In the rare cases in which CT brain scans are done with intravenous contrast, doctors are looking specifically for an infection or tumor in patients who cannot get an MRI.

#### Angiograms

Using fast injection of intravenous contrast and fast scanning, CT can now be used to get a very detailed look at blood vessels throughout the body, including:

- Vessels of the head and neck, to look for aneurysm, atherosclerosis, or dissection.
- Vessels of the lungs, to look for pulmonary embolism.
- Vessels of the heart (coronary CTA), to look for plaque or stenosis.
- Aorta, to look for aneurysm or dissection.
- Vessels of the arms and legs, to look for atherosclerosis.

#### Chest

- CT of the chest is used to look for masses (especially metastases from a known cancer) in the lungs or surrounding area; this is generally done with contrast.
- It can also be used to evaluate generalized lung disease (such as pneumonia or emphysema) in more detail than can be seen on a chest x-ray; this is generally done without contrast.

#### Abdomen/Pelvis

- CT is the study most often used to assess for infection or tumor in the abdomen and pelvis, because of its superior ability to delineate anatomic detail.
- With children and young women, CT in the pelvis should be avoided if possible.
- When done without contrast, it is usually performed to look for kidney stones.
- When done with contrast, it can be used to evaluate for tumors, appendicitis, bowel obstruction, and many other pathologies.

## Extremities

- CT of the arms and legs, when not done as part of an angiogram, is most commonly used to evaluate the bones for a fracture that is not clearly visible on x-ray.
- CT is the best exam for bony detail.

## Skull

- CT can be used to evaluate the skull base for fractures and inflammation, especially of the middle ear.

## RADIATION DOSE

### Radiation Dose

The amount of radiation received from most CT examinations is significant, because of the use of x-rays from all angles around the patient at multiple levels. For this reason, CT is used less often in young patients and in areas that are particularly sensitive to radiation exposure. For example, the ovaries of a young female are very radiosensitive (see *WCC Note*, Volume 1, Issue 2), so a CT of the pelvis would be avoided if possible in such a patient. In addition, CT is not used with pregnant women unless the procedure is considered vital to the health of the mother.

### Effective Radiation Dosage (in MilliSieverts):

Average background dose in the U.S. . . . . .	3.6 mSv/year
Three-hour commercial airline flight . . . . .	0.015 mSv
Chest X-ray (two views) . . . . .	0.05 mSv
Head CT scan . . . . .	1-2 mSv
Chest CT scan . . . . .	5-7 mSv
Abdomen and pelvis CT scan . . . . .	6-8 mSv
Selective diagnostic coronary angiography . . . . .	3-6 mSv
Coronary CT angiography . . . . .	8-13 mSv

## PROS AND CONS

### ADVANTAGES AND DISADVANTAGES OF CT

#### ADVANTAGES

- Detects calcium or stones, bone, air, gas, blood, water
- Fast
- Moderate cost
- Reproducibility (consistent on the same machine type)
- Interpretation not as challenging as MR
- Usually more sensitive than x-ray
- Reasonable contrast costs
- Replaces invasive angiography
- Contrast allergy uncommon
- Easy to measure mass size
- Easy to reconstruct

#### DISADVANTAGES

- Poorly distinguishes soft tissues from tumors
- Poor resolution of cartilage
- Poor distinction of soft tissues from water or proteinaceous fluid
- Moderate cost
- Many different vendors and scanner types
- Radiation dose is significant
  - May have to avoid in children
  - May have to avoid certain organs that are sensitive to radiation (testes, ovaries, and breasts)
- May require contrast injection for diagnosis
- Moderate volume of contrast needed (approximately 100cc)
- Contrast allergy uncommon, but more common than with MRI

### NEXT WEEK: MAGNETIC RESONANCE IMAGING (MRI)